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NAVAL POSTGRADUATE SCHOOL

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THESIS

DISPERSION SENSITIVITY OF THE EIGHT INCH
ADVANCED RAMJET MUNITIONS TECHNOLOGY
PROJECTILE DUE TO WIND
AND MINOR THRUST ERRORS

by

Steven Ronald Poole

September 1984

Thesis Advisor:

A. E. Fuhs

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Prepared for: Colonel R. Larriva
Defence Advanced Research
Projects Agency
Arlington, VA 22209

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Dispersion Sensitivity of the Eight Inch
Advanced Ramjet Munitions Technology Projectile
Due to Wind and Minor Thrust Errors

by

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Major, Canadian Forces
B Sc., College Militaire Royale De Saint Jean, 1975

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN ENGINEERING SCIENCE

from the

NAVAL POSTGRADUATE SCHOOL
September 1984

ABSTRACT

Advanced Ramjet Munitions Technology (ARMT) is an ongoing project within the Defence Advanced Research Projects Agency (DARPA) to research ramjet munitions. The ARMT eight inch projectile uses ramjet thrust for a boosted trajectory, but operates on a thrust drag balance concept to create a pseudo vacuum trajectory during powered flight. The trajectory was analyzed using an IBM 370 computer simulation for three and five degrees of freedom. Work was also done to adapt the Ballistics Research Laboratories six degrees of freedom program to the IBM system. Projectile aerodynamic and mass properties were obtained from the Norden Systems Wind Tunnel Data. Dispersion from the vacuum trajectory due to wind prior to ramjet burnout proved minor. Dispersion due to constant thrust errors under 5% was within a 600 foot radius at terminal guidance over a range of 33 miles.

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TABLE OF SYMBOLS AND ABBREVIATIONS

ABBREVIATIONS:

AIFS -ADVANCED INDIRECT FIRE SYSTEM

ARMT -ADVANCED RAMJET MUNITIONS TECHNOLOGY

BRL -BALLISTICS RESEARCH LABORATORY

IODE -INTERACTIVE ORDINARY DIFFERENTIAL EQUATION
SOLVER

NPGS -NAVAL POSTGRADUATE SCHOOL

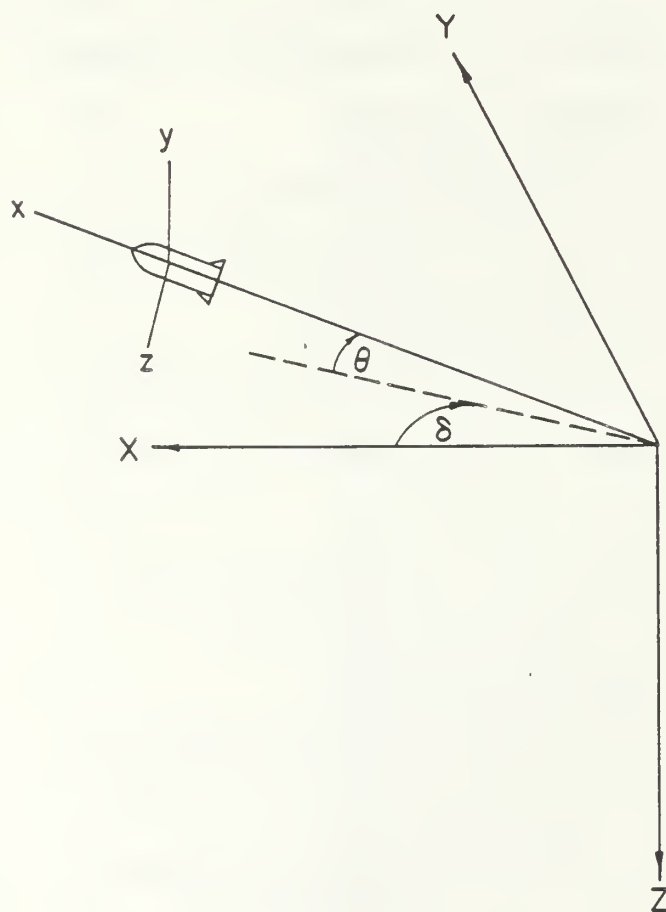
SYMBOLS:

FORMULA	PROGRAMS	DESCRIPTION	UNITS
α	A	angle of attack	radians
β	B	sideslip angle	radians
δ	DE	angle between body axis and inertial axis (yaw plane)	radians
γ	GA	angle between inertial axis and relative wind,yaw plane	radians
λ	LAMBDA	wavelength	feet
ρ	RO	air density	lbf-s ² /ft ⁴
ω	-	angular velocity	rads/sec
Ω	O	angle between relative wind and inertial axis (pitch plane)	radians
θ	THE	angle between body axis and inertial axis(yaw)	radians
C_d	CD	drag coefficient	

C_{do}	CDO	zero lift drag coefficient	
C_l	CL	lift coefficient	
C_{l_α}		slope lift coefficient	
C_m	CM	moment coefficient	
C_{m_α}	CMA	slope moment coefficient	
C_{mq}	CMT	damping coefficient	
X_{cp}		centre of pressure location(from spike)	inches
X_{cg}		centre of gravity location(from spike)	inches
C	C	thrust error coefficient	
d	DI	projectile diameter	inches
D	DRAG	Drag	lbf
D_w		Drag due to wind	lbf
f		frequency	Hz
g	G	gravity	ft/sec
I	I	moment of inertia	slug-ft
I_{sp}	ISP	specific impulse	"sec"
L	L	lift	lbf
L_w		net lift due to transients	lbf
m	M	mass	lbm
q	Q	dynamic pressure	lbf/ft ² -s ²
U	V	relative wind	ft/sec
V		initial velocity projectile	ft/sec

Vcg	VCG	centre of gravity velocity	ft/sec
Vw	VW (3 deg) VWXY(5 deg) VWXZ(5deg)	wind velocity	ft/sec
Vwo		initial wind speed	ft/sec
X	X	range	ft
Y	Y	crossrange	ft
Z	Z	height	ft

GEOMETRIC NOMENCLATURE:



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I would be remiss if I did not thank my wife, Marie Josee, and my two children,Crista and Eric, for helping create the atmosphere I needed to succeed in the academic environment.

I. INTRODUCTION

A. ARMT OPERATIONAL CONCEPT

Conventional artillery uses unguided projectiles to destroy a variety of targets including armored vehicles. Ballistic information and professional experience are used to direct fire onto a target with little chance of a direct hit in the first few rounds. A forward observer provides feedback to the guns for correction until the target is destroyed with subsequent rounds. Generally this approach is limited to the 30 kilometer range and often point target locations are not known.

The ARMT projectile, formerly called AIFS, changes the conventional concept by providing a fire and forget, boosted and terminally guided projectile with a highly predictable trajectory. Conventional heat seekers and target identification systems are short range and require a blunt nose which has high drag. Active radar is not practical. Long ranges of 60 kilometers are achieved by using solid fuel ramjet propulsion with an axisymmetric air inlet spike. An accurately predicted trajectory is achieved by ensuring thrust equals drag to produce zero axial acceleration and create a pseudo-vacuum trajectory during powered flight. At a preset time (near ideal condition ramjet burnout) the inlet spike is discarded and canards are deployed for

terminal guidance control. A passive or reflected target energy system will be used for terminal guidance. Research is ongoing and sponsored by DARPA. Projectile characteristics are at Appendix A.

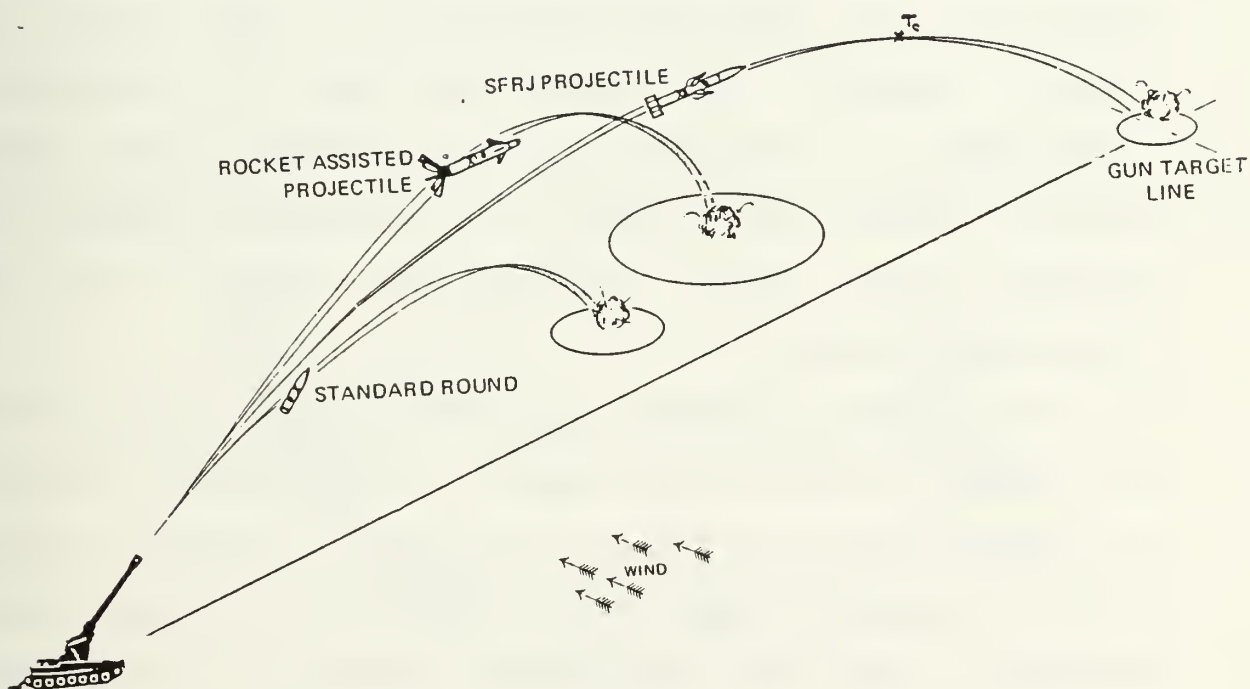


Figure 1-1 ARMT Trajectory Concept

B. THRUST DRAG BALANCE CONCEPT

Balanced thrust drag implies that the thrust equals the drag vectors during powered flight. The aim of the balance is to negate meteorological variations throughout the trajectory by reducing all force vectors to zero except gravity. The resulting pseudo-vacuum trajectory is highly predictable. The balance is accomplished by measuring axial acceleration and maintaining it at zero. Appendix B explores this concept in detail. The potential errors include transients due to wind induced reactions and measurement errors in the technical application of the balance in flight. Further, any asymmetries such as aerodynamic misalignment or thrust will produce a lateral force which must be offset by a small roll rate (sixth degree of freedom). This allows longitudinal forces to be the significant forces.

The concept of thrust drag balance is best demonstrated in Figures 1-2 and 1-3. In Figure 1-2 the centre of gravity of the projectile is flying at an angle of attack (α) with a velocity vector (V_{cg}) relative to a fixed earth reference frame. The aerodynamic forces are lift (L) and drag (D). Assuming static stability and neglecting transient dynamics, the angle of attack becomes zero, which

reduces lift to zero. If thrust equals drag then only the gravitational force exists.

If a crosswind (V_w) is applied, the projectile corks into the wind because of the aerodynamic force acting on the centre of pressure. Adjusting the thrust and again assuming static stability the drag can be offset as shown in Figure 1-3 by applying the correct thrust. For future reference the component of drag normal to the plane containing V_{cg} is D_w .

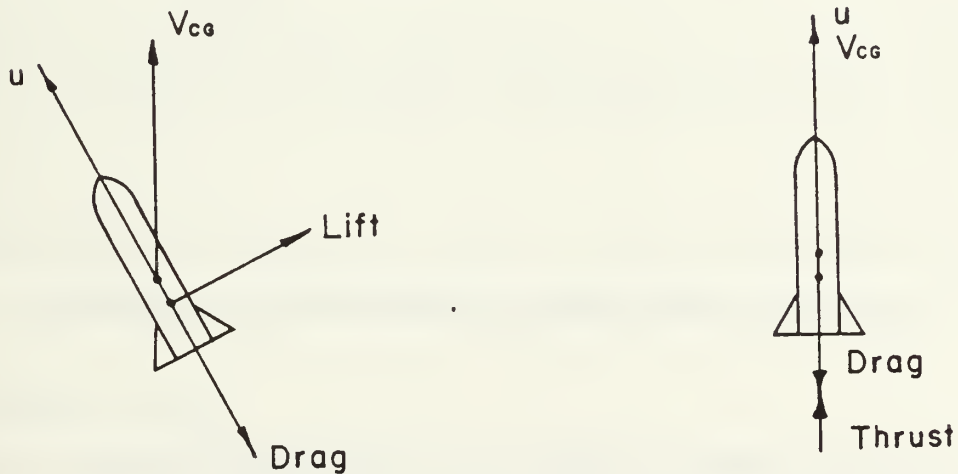


Figure 1-2 Projectile Dynamics Thrust Equals Drag

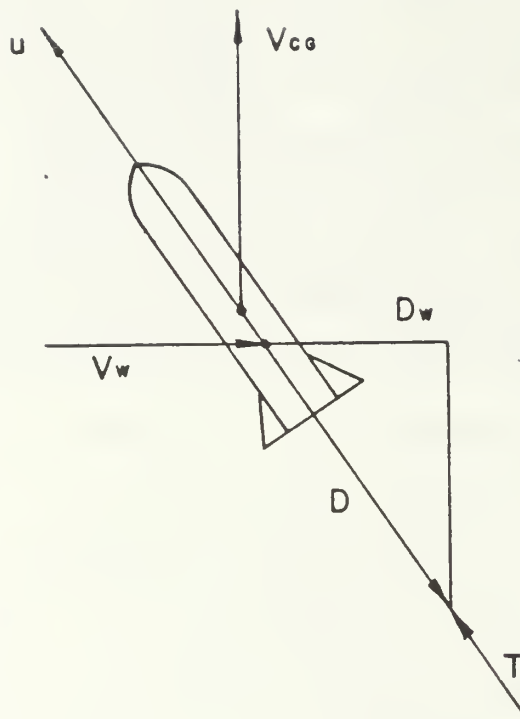


Figure 1-3 Projectile Dynamics With Crosswind

If a tailwind or headwind is applied, thrust is adjusted to compensate in the same manner.

The dynamics or transient effects due to wind which create damped oscillatory motion have a cumulative net lift effect(as shown in Figure 1-4) as angle of attack is proportional to lift. The area under the curve in Figure 1-4

does not average to zero due to the damping. For future reference this lift due to wind will be referred to as L_w .

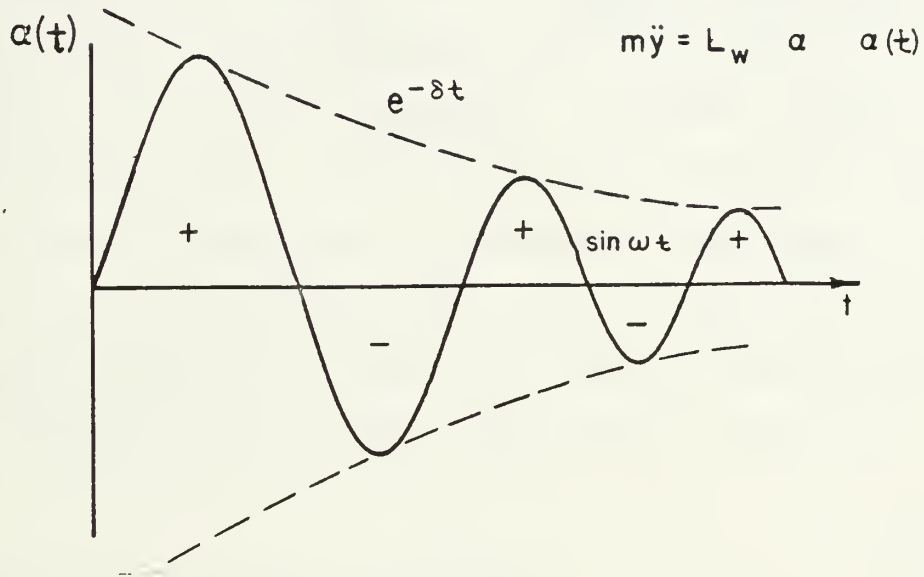


Figure 1-4 Angle Of Attack Versus Time

Calculations integrating $\alpha(t)$ twice to demonstrate the above in the yaw or pitch plane are at Appendix B.

C. THESIS SCOPE

It is emphasized that the scope of this thesis is to analyze dispersion from the pseudo-vacuum trajectory at terminal guidance time for the eight inch ARMT projectile. In colloquial terms the "basket" from which the projectile will be guided to target was determined. Further, this basket is based on thrust errors and wind effects for a

launch angle of 45 degrees and muzzle velocity of MACH 2.2 at sea level. Linearized aerodynamics were used in all calculations. No attempt was made to establish a "footprint" for projectile impact.

II. TRAJECTORY ANALYSIS METHODOLOGY

A. VACUUM TRAJECTORY ANALYSIS

A short and simple BASIC program was written to establish the vacuum trajectory and fuel burn time of the projectile in a two dimensional scenario where thrust exactly equaled drag. The Standard U.S. Atmosphere was used and the drag coefficient linearized [Reference 1]. The program listing and baseline data are at Appendix D. The key parameters and equations used are listed at Appendices A and D. The baseline pseudo-vacuum trajectory is shown in Figure 2-1.

B. THREE-DEGREES-OF-FREEDOM MODEL

The computer simulation was established using the Interactive Ordinary Differential Equation (IODE) library program at NPGS. A listing of the three degrees of freedom equations is in the IODE specifications at Appendix E. The simulation is based on wind tunnel results from Norden Systems [References 2 and 3] and assumes a horizontal plane at 30000 feet altitude. This height was chosen as significant flight time is at altitude and the time of flight in this plane was near actual flight time. Primarily the model was used to study crosswind effects but resonance with the projectile short period was simulated. Different thrust

scenarios were also used. Figure 2-2 depicts the model in the X-Y plane.

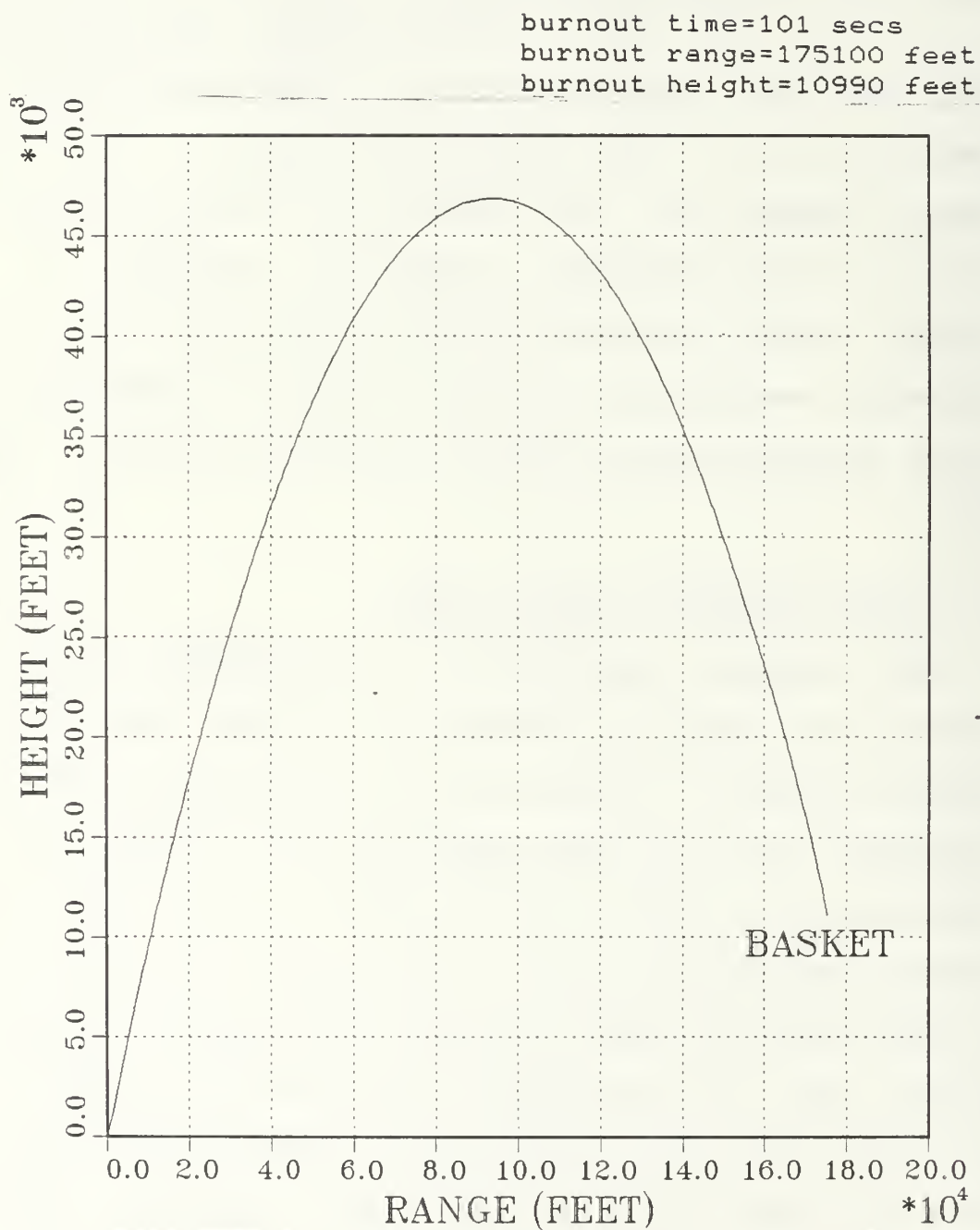


Figure 2-1 ARMT Pseudo-vacuum Trajectory

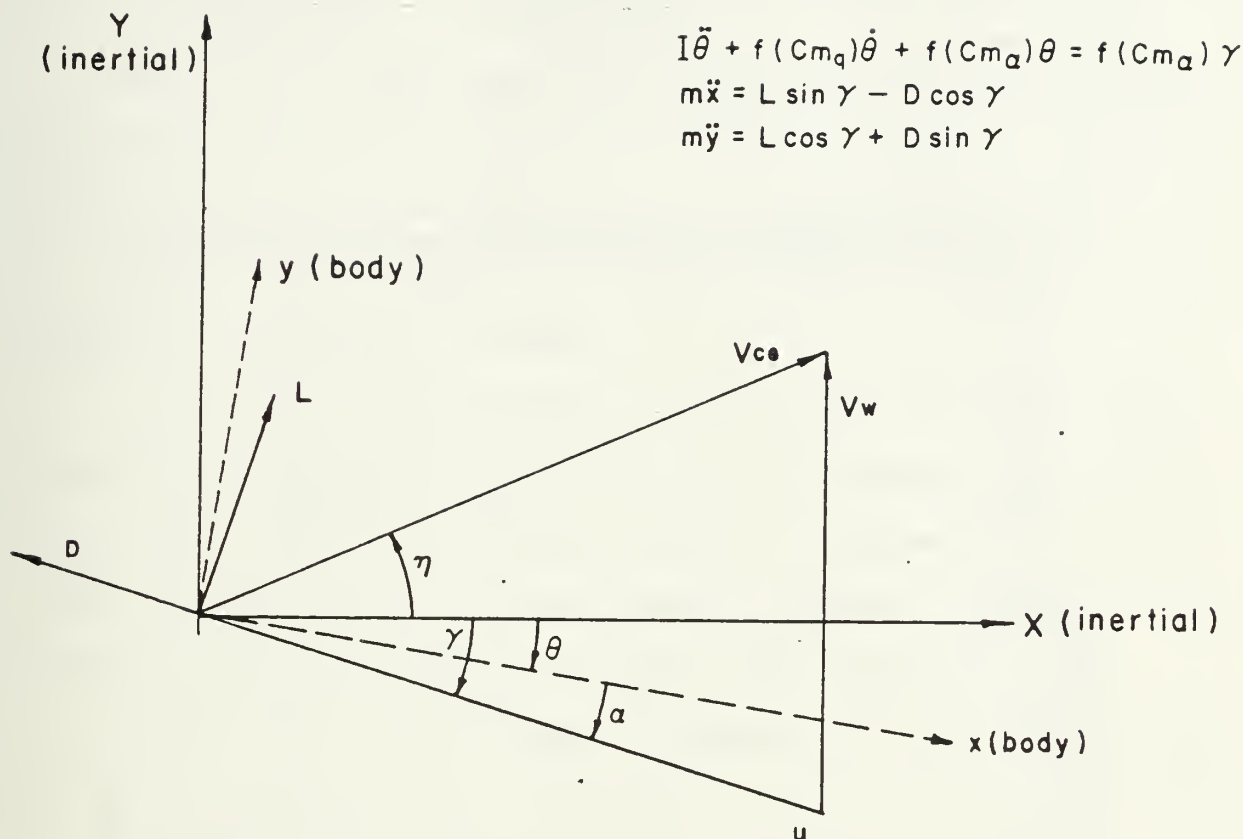


Figure 2-2 Three Degrees Freedom Model (Yaw Plane)

The crosswinds were varied in intensity and duration to analyze crossrange dispersion. As well thrust was varied as a function of drag by scaling the drag. Cm_q predictions were approximately -190 to -205 by Norden Systems [Reference 2] and an analysis was done to determine the effects of varying this damping coefficient. To further study the projectile characteristics, trajectories were simulated with no thrust or mass attenuation with varying wind profiles. Figure 2-3 ,

shows the baseline three-degrees-of-freedom trajectory of thrust equals drag with no wind.

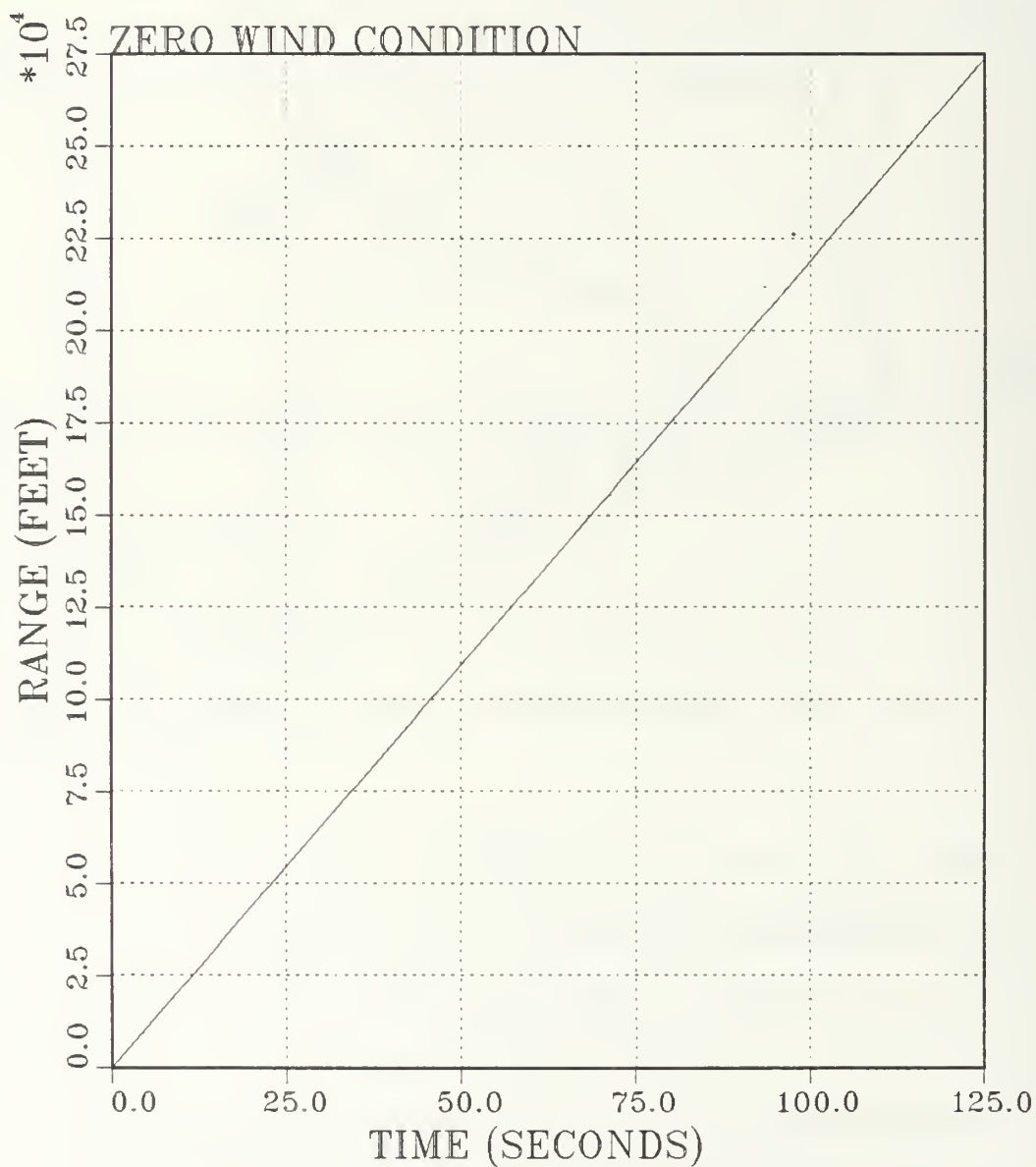


Figure 2-3 Baseline Three-Degrees-Of-Freedom Trajectory

C. FIVE-DEGREES-OF-FREEDOM MODEL

Again the IODE program was used to solve a five degrees of freedom system of equations. The roll plane was neglected for the following reasons:

- the program could not accept sufficient functions to define six degrees of freedom.

- the fins are expected to damp out initial spin due to gun rifling (900 RPM) in the first few seconds of flight. Sufficient spin to average projectile asymmetry errors to zero but not enough to significantly affect dynamics will remain.(ie. gyroscopic effects and Magnus effects)

- the initial spin damping dynamics are beyond the scope of this thesis.

The projectile was assumed to be axisymmetric allowing for ease of calculations in the yaw and pitch planes. Figures 2-2 and 2-4 depict the yaw and pitch planes for the model, respectively.

A listing of the equations is provided in the IODE specifications at Appendix F. Trajectory simulations were run with varying wind profiles and thrust error scenarios. Terminal guidance time (T_c) was determined by the baseline five degrees of freedom trajectory shown at Figure 2-1 as 101 seconds. This trajectory has no wind and thrust exactly equaled drag until discard of the air inlet spike and

canard deployment. All simulations assumed a 45 degree launch angle and Mach 2.2 muzzle velocity. Dispersion from the pseudo-vacuum trajectory was measured at terminal guidance time including the following variables:

- X=range at 101 seconds
- Y=crossrange at 101 seconds
- Z=height at 101 seconds
- T_b=burnout time
- V_{cg}=speed at time 101 seconds

Dispersion is defined as the difference between value for perturbed trajectories and the baseline trajectory.

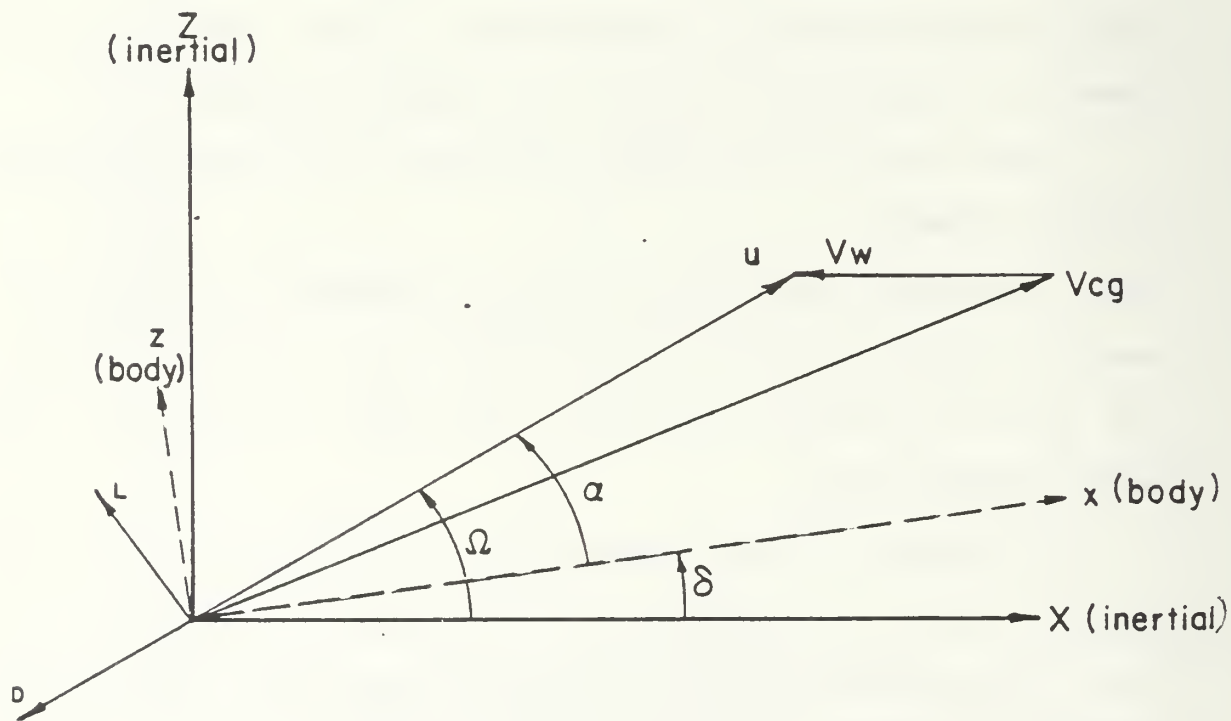


Figure 2-4 Five-Degrees-Of-Freedom Pitch Plane Model

D. SIX-DEGREES-OF-FREEDOM MODEL

The Ballistics Research Laboratories (Aberdeen) six degrees of freedom model HTRAJ was obtained and adapted for use on the NPGS IBM 370 system. The adapted listing is included as Appendix G. Program compilation was achieved but output data was not satisfactory due primarily to input data syntax problems. Further, the program requires extensive modification to be able to vary thrust as a function of drag with the ease of the previous models already described. Time was not available to correct these problems. Detailed documentation on the program HTRAJ is available through BRL.

III. TRAJECTORY RESULTS

A. THREE DEGREES OF FREEDOM

1. Crosswind And Thrust Error Sensitivity

Figures 3-1 and 3-2 show the effects of constant thrust errors as a percentage of drag with no wind. Recall that the three-degrees-of freedom trajectory is at constant altitude. The figures therefore represent a thrust error sensitivity in terms of burn time and range variations due to drag or thrust. The trajectories all pass nearly through the 218000 foot range mark at $t=100$ seconds, but the burnout ranges are significantly different due to the varying burn times resulting from projectile thrust. Figure 3-2 demonstrates the obvious conclusion that the burnout time decreases as thrust increases.

Figure 3-3 combines the effects of constant crosswinds and thrust errors to demonstrate resultant cross range dispersion. The constant wind velocity lines are very nearly linear, and the pattern is essentially a shift about the zero-zero point. If thrust is less than drag, the dispersion is in the direction of the wind vector. If thrust is greater than drag then the overcompensation produces a dispersion opposite to the wind vector.

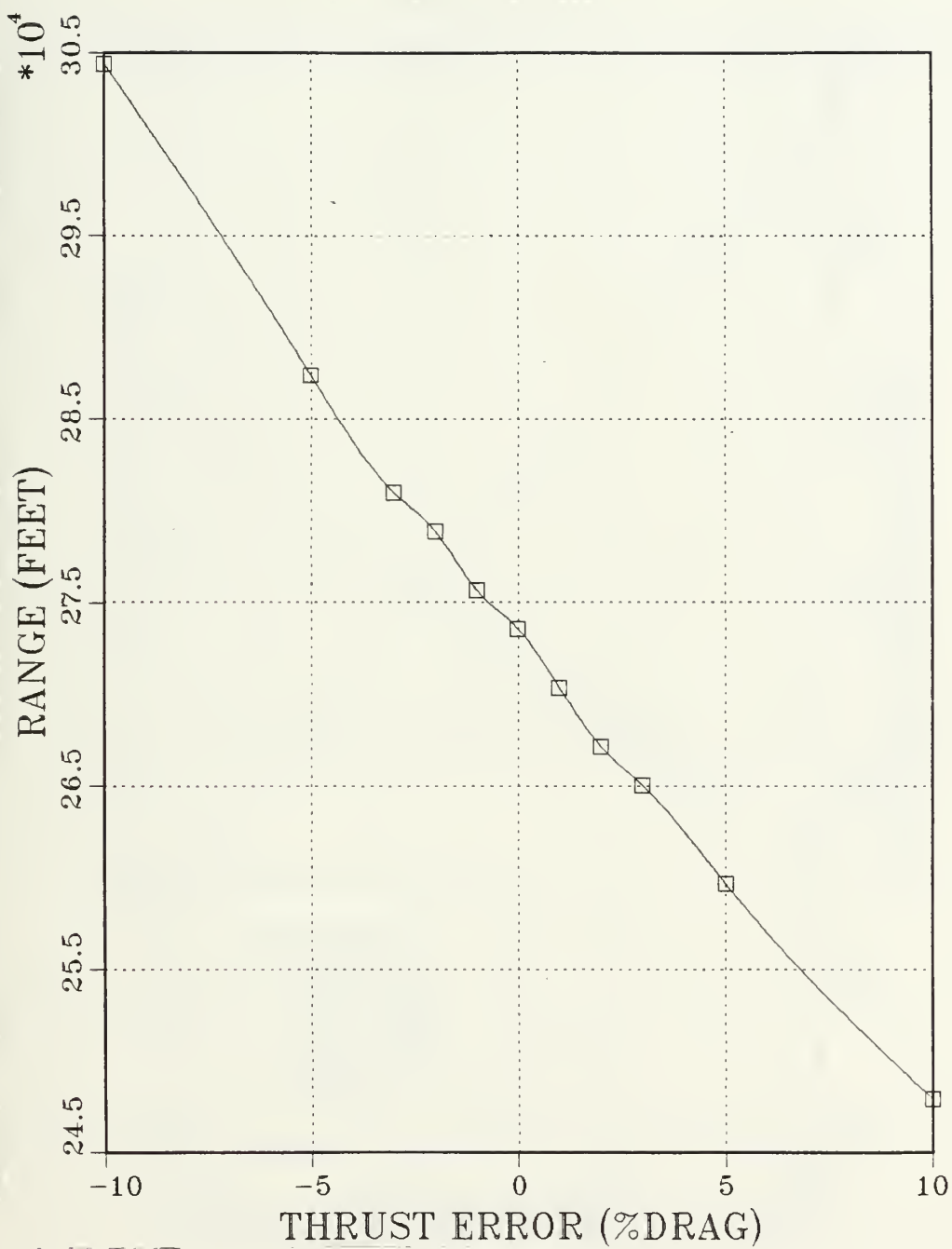


Figure 3-1 Thrust Error Sensitivity (Range)
Three Degrees Of Freedom

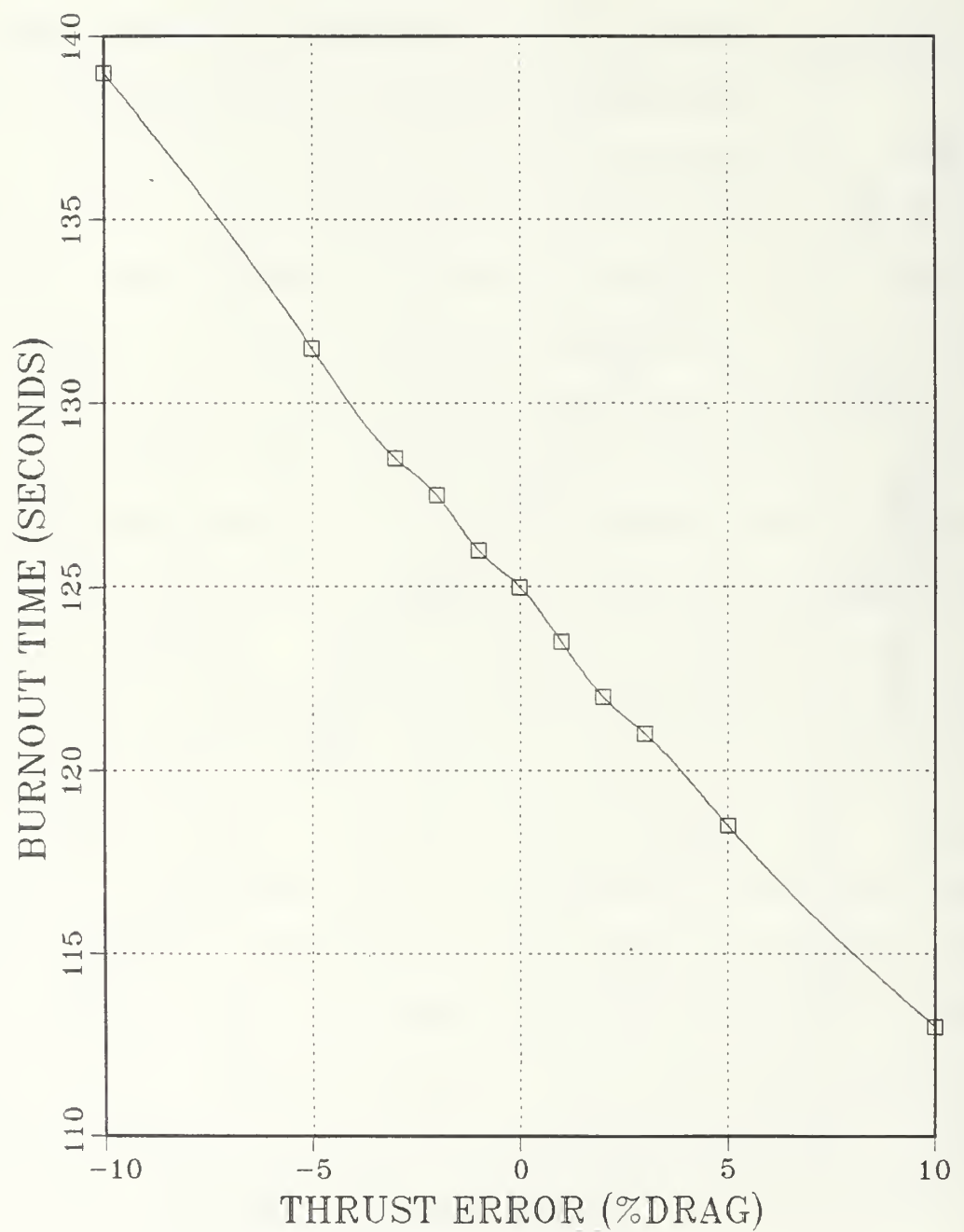


Figure 3-2 Thrust Error Sensitivity (Burntime)
Three Degrees Of Freedom

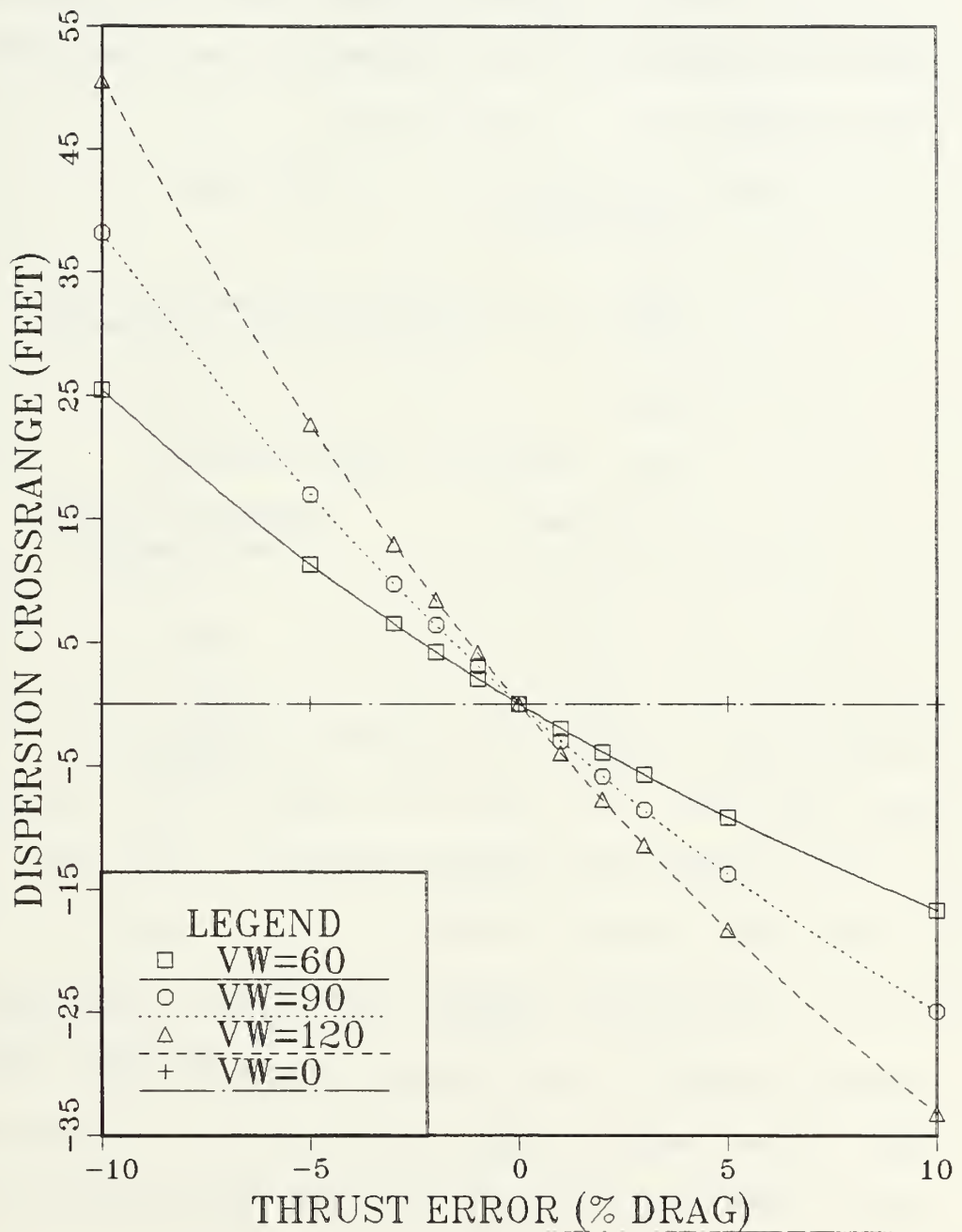


Figure 3-3 Crosswind Sensitivity Three Degrees Of Freedom

Of interest was the dispersion due to the same wind profiles without thrust or mass loss. This represents an absolute dispersion with a given wind profile. These results are in Table 3.1.

Table 3.1 No Thrust Crosswind Effects
Three Degrees of Freedom

Thrust=0 t=125 seconds	
vw (ft/sec)	dispersion (feet) crossrange
0	0
60	195.76
90	293.80
120	392.02

The data clearly shows that crosswinds have a minimal effect in the thrust scenarios. The dispersion in the thrust-equals-drag case is due to the transients (Lw) and is negligible as well. This is illustrated at Table 3.2.

Table 3.2 Dispersion Due to Net Lift
from Transients

Thrust=drag	
vw (feet/sec)	dispersion (feet) crossrange
0	0
60	.018
90	.027
120	.036

Angle of attack damped to virtually zero during the trajectories (see Figure E-3) but the absolute maximum values were also recorded. Figure 3-4 demonstrates the relation between angle of attack (α) and the wind velocity. Thrust errors had virtually no effect on the angle of attack magnitude.

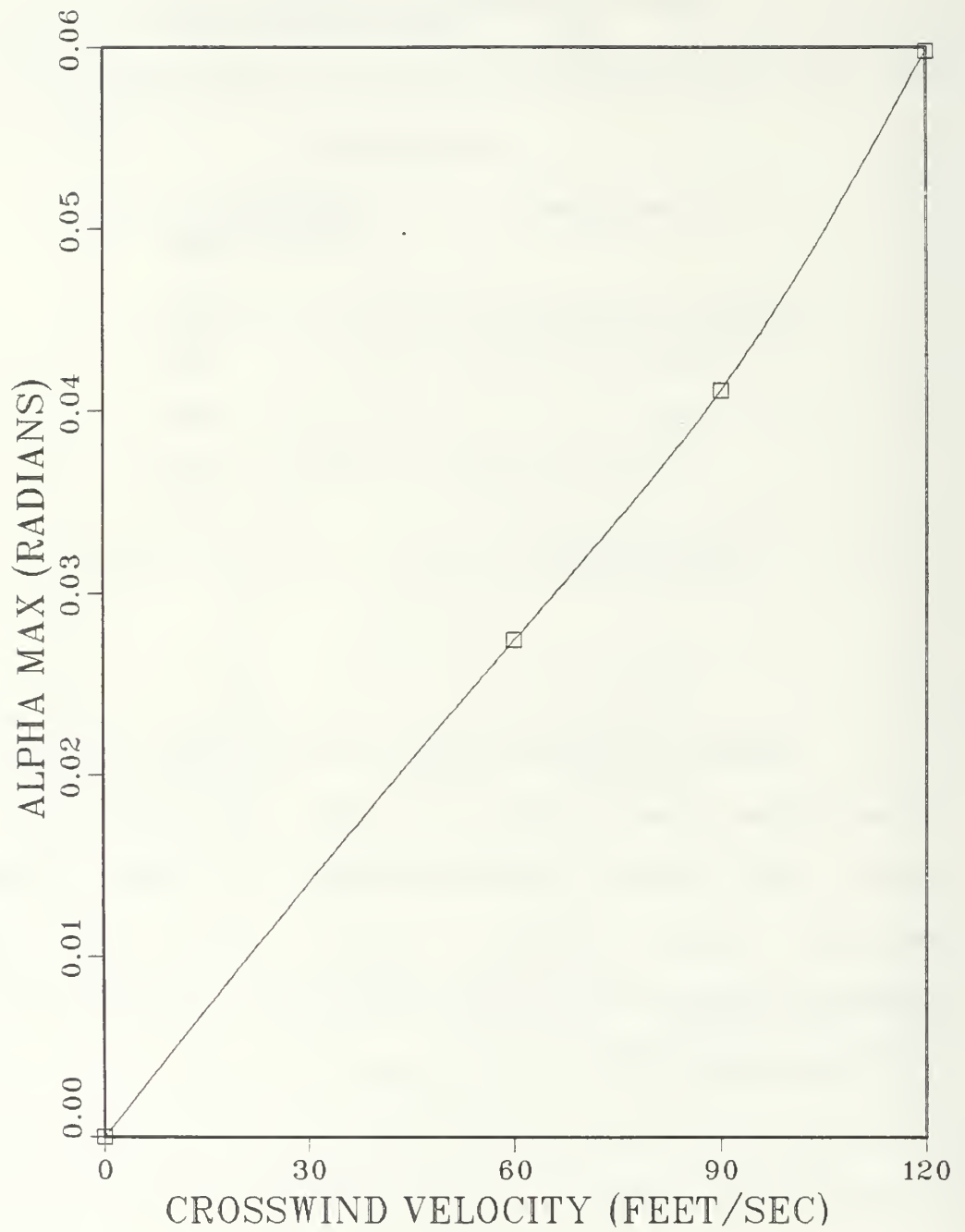


Figure 3-4 Wind Effects On Maximum Angle Of Attack

2. Damping Coefficient Effects

The magnitude of C_{mq} was determined to be approximately -200 in the flight speed ranges of the ARMT projectile [Reference 4]. To determine if this coefficient significantly affected dispersion C_{mq} was varied from 0 to 1.9×10^6 and the dispersion recorded. Figure 3-5 shows the relation between C_{mq} and dispersion (crossrange) with a constant wind of 60 feet/second and time of 125 seconds.

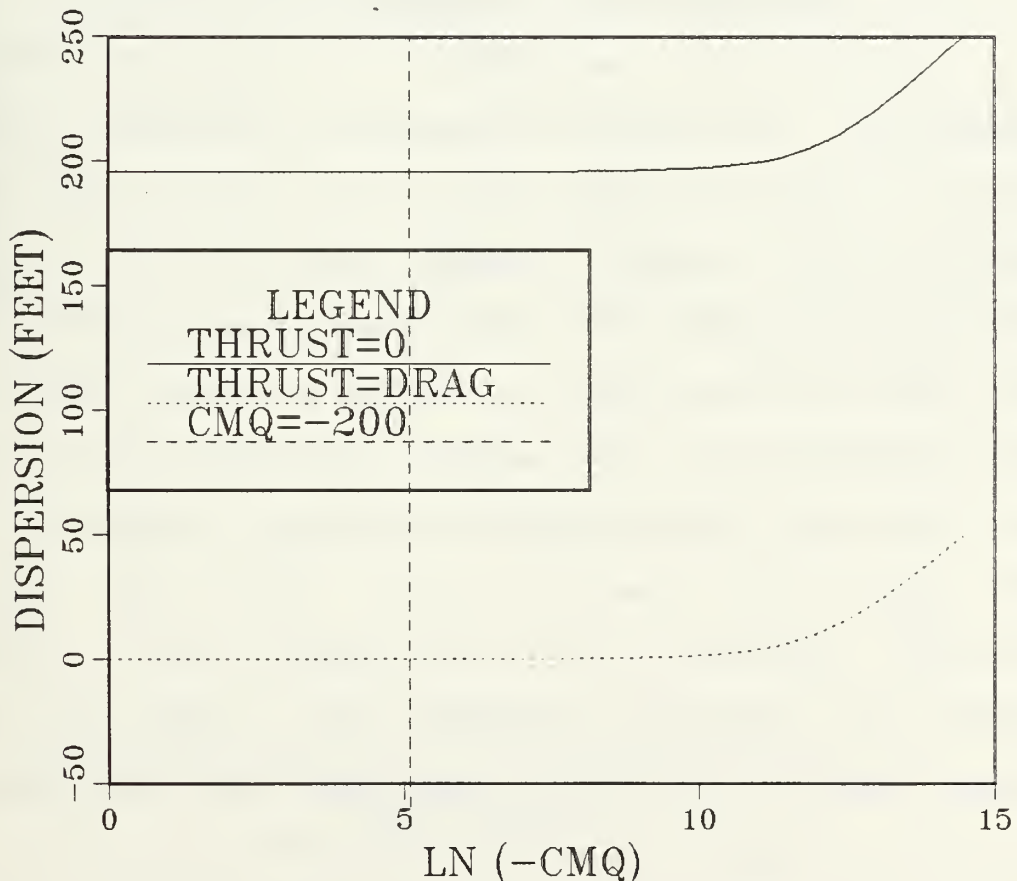


Figure 3-5 Damping Coefficient Effects

Careful examination of Figure 3-5 shows that dispersion increases slightly for realistic values of C_{mq} and is therefore proportional to C_{mq} . Due to the small sensitivity of dispersion to C_{mq} for all practical purposes one can conclude dispersion is independent to C_{mq} . (The increased dispersion proportional to C_{mq} can be explained as the difference in the areas under a highly damped sinusoid versus a non-damped sinusoid is considerable.)

3. Sinusoidal Wind Analysis

To test the effects of phase angles and wavelengths on the projectile dynamics a sinusoidal wind was input to test the model. The wind (V_w) was of the form $V_o \sin(2 \text{ PI } V_o t / \lambda + \text{phase})$ where V_o was set at 60 feet/second. Figures 3-6 and 3-7 show the trajectories for the sine and cosine winds to burnout at thrust equal to 90% drag. ($\lambda = \text{range}$ and $\lambda = .5 \text{ range}$) Of note is the fact that the sine wind produces a continuous dispersion while the cosine wind does not when thrust does not equal drag. This discovery led to an expanded study of different phase and wavelength sinusoidal wind inputs for various thrust scenarios. As well a simplified model was constructed as shown at Figure 3-8 and calculations confirmed the three degrees of freedom model results. Figures 3-9 and 3-10 depict the results of the calculations.

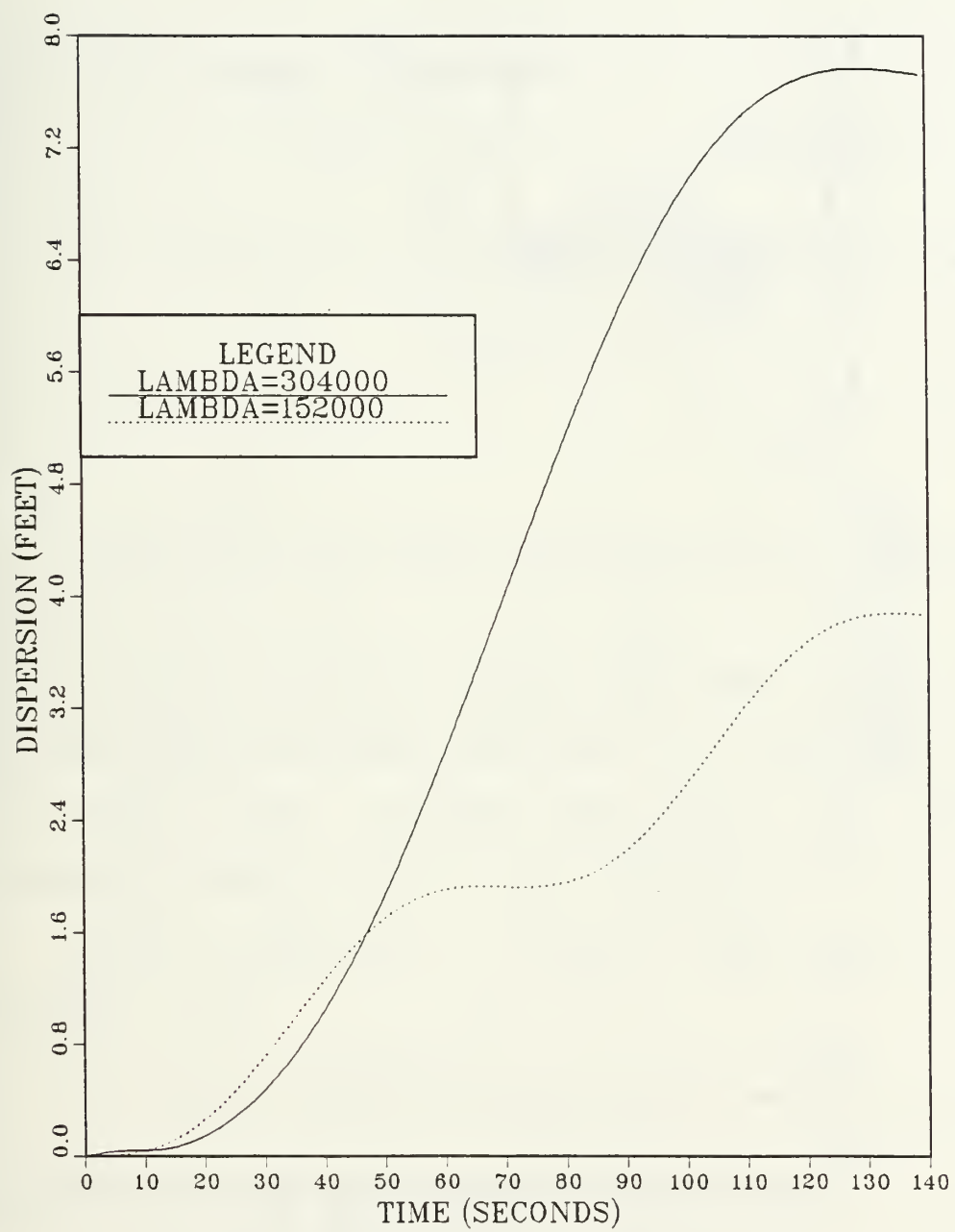


Figure 3-6 Sinusoidal Wind Effects (Sine)

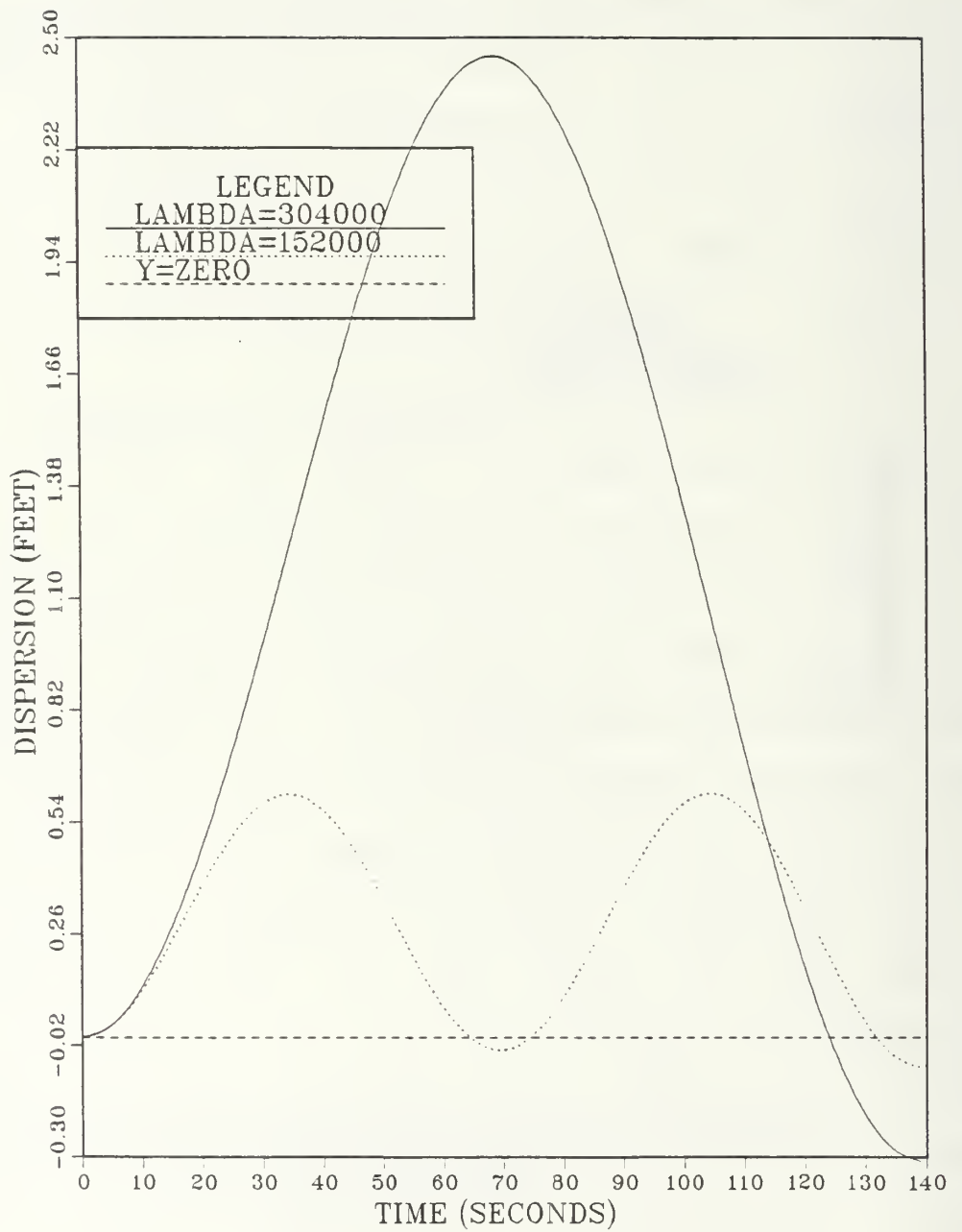


Figure 3-7 Sinusoidal Wind Effects (Cosine)

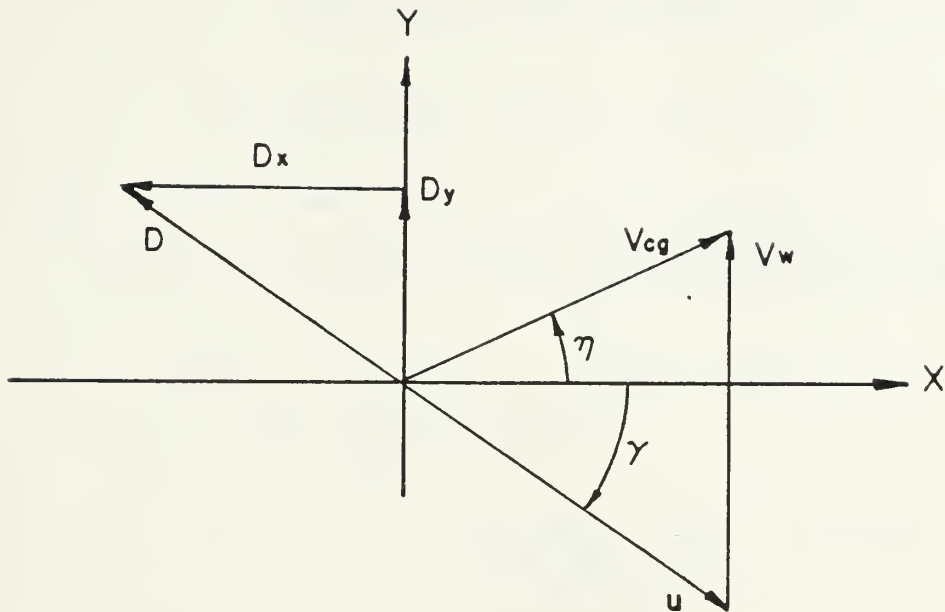


Figure 3-8 Simplified Three Degrees Of Freedom Model

The simplified model was used to analytically evaluate the crossrange dispersion (y) in the cases of sine and cosine winds to confirm the validity of the three-degrees-of-freedom model. Calculations follow:

General equations of motion in the y direction from Figure 3-8 are:

$$M \frac{dV_y}{dt} = D_y \text{ which approximately equals } D(V_w - V_y)/V_{x0}$$

if $V_{x0} = V_0 = \text{constant}$. Then transforming the equation we get:

$$dV_y/dt + D/(M V_0) V_y = D/(M V_0) V_w(t)$$

or in time differentiated notation:

$$\ddot{y} + B \dot{y} = B V_w(t) \quad \text{if } D/(M V_o) = B$$

If a cosine wind $V_w(t) = V_{wo} \cos(2 \pi V_o t / \lambda)$ is applied and the differential equation solved we have:

$$y(t)/\lambda = K \left[e^{-Bt} - \cos(2 \pi V_o t / \lambda) + \frac{D \lambda \sin(2 \pi V_o t / \lambda)}{2 \pi m V_o^2} \right]$$

$$\text{let } K = \frac{2 \frac{1}{2} m V_o^2 V_{wo}}{D \lambda V_o} \frac{1}{1 + \left[\frac{4 \pi D \lambda}{1/2 m V_o^2} \right]^2}$$

Figure 3-9 graphically depicts the results as t increases. A zero asymptote is observed and this conforms with model results.

Now if a sine wind $V_w(t) = V_{wo} \sin(2 \pi V_o t / \lambda)$ is applied and the differential equation solved:

$$y(t)/\lambda = K \left[\frac{D \lambda}{4 \pi \frac{1}{2} m V_o^2} (1 - \cos(2 \pi V_o t / \lambda)) - \sin(2 \pi V_o t / \lambda) + \frac{4 \pi (\frac{1}{2} m V_o^2)}{D \lambda} (1 - e^{-Bt}) \right]$$

Figure 3-10 graphically depicts these results as t increases. The asymptote is

$$K \left[\frac{(4 \pi \frac{1}{2} m V_o^2)}{D \lambda} (1 - e^{-Bt}) \right]$$

and this conforms to the model also.

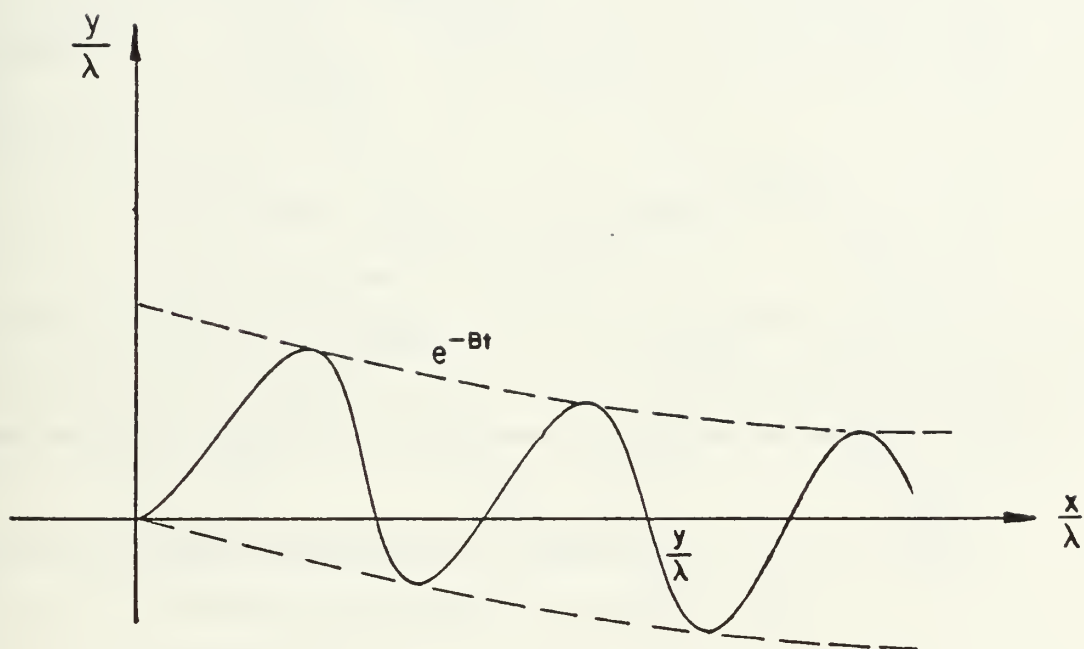


Figure 3-9 Cosine Wind Analysis Results

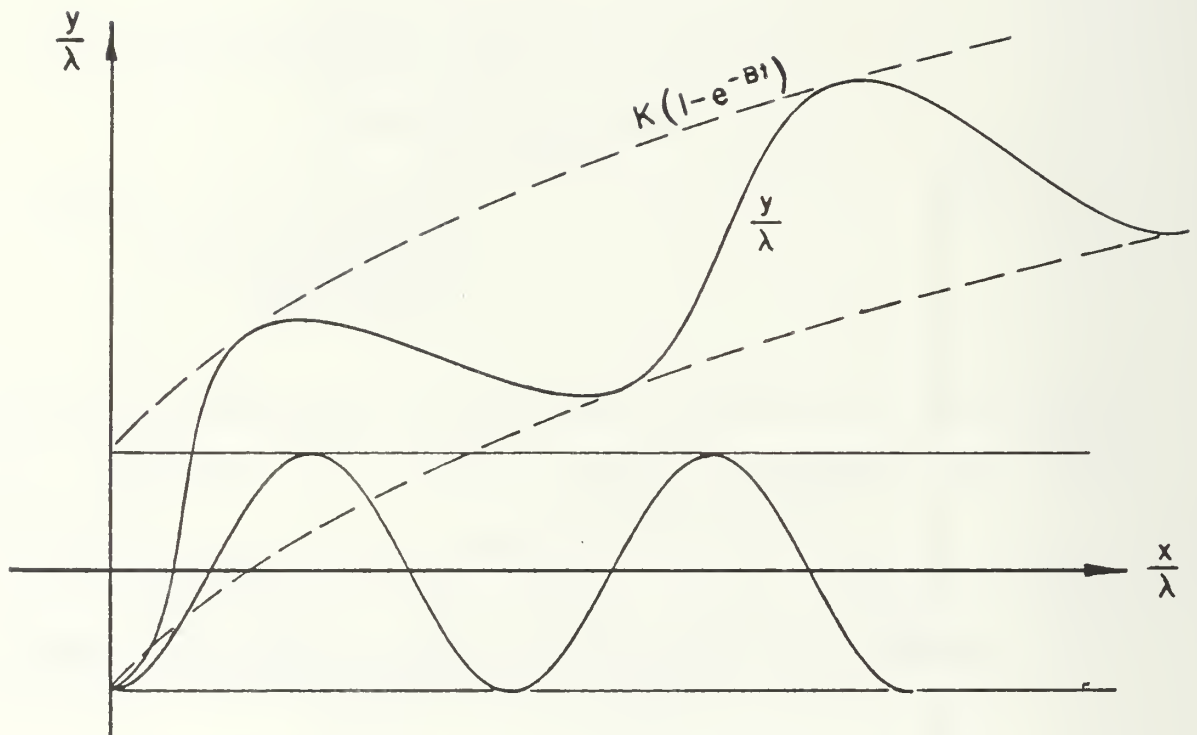


Figure 3-10 Sine Wind Analysis Results

The constant wind case was also derived:

$V_w(t) = V_w$ and the solved differential equation is:

$$y(t) = V_w t - V_w m V_o / D e^{-Bt}$$

and as t increases y approaches $V_w t$.

Specific calculations were done to confirm dispersion results at burnout. The calculations were based on:

$$y = dy/dx \times = 1/V_o dy/dt \times$$

$$V_{wo} = 60 \text{ ft/sec}$$

$$V_o = 2190 \text{ ft/sec}$$

$$\lambda = 304000 \text{ ft}$$

$$t = \lambda / V_o$$

$$D = 1/2 \rho V_o^2 A C_d (=226 \text{ lbf})$$

$$\text{Thrust} = .9D \text{ therefore } D = 22.6 \text{ lbf}$$

$$M = 225 \text{ lbm}$$

Taking the time derivative of the cosine wind $y(t)$ dispersion formula derived earlier we get

$$dy/dt = K \left[-B e^{-Bt} + \frac{2 \text{ PI } V_o}{\lambda} \sin(2 \text{ PI } V_o t / \lambda) + \frac{D \lambda}{4 \text{ PI } 1/2 m V_o^2} \cdot \frac{2 \text{ PI } V_o}{\lambda} \cos(2 \text{ PI } V_o t / \lambda) \right]$$

at $t = \lambda/V_0$ the equation becomes:

$$dy/dt = K(-Be^{-B\lambda/V_0} + B)$$

and substituting the values into the approximationn
for y ; $y=0$ ft.

Now, performing the same operations on the sine
wind dispersion equation :

$$dy/dt = K \left[\begin{aligned} &\frac{D\lambda}{4 \text{ PI } 1/2 m V_0^2} \cdot \frac{2 \text{ PI } V_0 \sin(2 \text{ PI } V_0 t/\lambda)}{\lambda} \\ &- \frac{2 \text{ PI } V_0 \cos(2 \text{ PI } V_0 t/\lambda)}{\lambda} + \frac{(4 \text{ PI } 1/2 m V_0^2)}{D\lambda} \cdot \\ &(Be^{-Bt}) \end{aligned} \right]$$

and at $t = \lambda/V_0$

$$dy/dt = K \left[\begin{aligned} &\frac{-2 \text{ PI } V_0}{\lambda} - \frac{4 \text{ PI } 1/2 m V_0^2}{D\lambda} \cdot Be^{-Bt} \end{aligned} \right]$$

and $y=20$ ft approximately.

Finally, taking the constant wind dispersion
formula and taking its derivative :

$$dy/dt = V_w - V_w e^{-Bt}$$

and $y=10$ ft approximately.

These results are consistent with the three-degrees-of-
freedom model considering the initial approximations.

To study the short period resonance phenomenom the
phase and wavelength wind variations were documented in

detail for a condition of thrust equal to 90% drag. Figures 3-11 to 3-13 show the crossrange dispersion effects from wavelengths of 5000 ($\lambda = .016$ range) to 303000 ($\lambda \neq \text{range}$) feet and the phase angle variations from 0 to 2 PI. At approximately 9850 feet the dispersion characteristics were no longer symmetric but remained under one foot. This is demonstrated at Figure 3-14. A crossrange dispersion contour was constructed at Figure 3-15 but this did not emphasize the resonance phenomenon sufficiently due to linearized aerodynamics and small dispersion magnitudes. The parameters that varied most significantly near resonance were angle of attack and burn time. Indeed, it is clear that the projectile is unstable in this region with a maximum angle of attack of 1.21 radians (70 degrees). Due to the increased angle of attack, drag increased and burn time decreased in the order of seven seconds (5%) compared to the baseline trajectory. This clearly affected the range at burnout. Due to large angle of attack the linearized aerodynamics are not valid. Projectile performance at wind resonance is worthy of additional analysis. It was decided to demonstrate resonance by plotting the maximum angle of attack (α) versus wavelength with different thrust/ drag scenarios. The resonance results are at Figure 3-16. The projectile natural frequency is estimated at 0.22 Hz. Resonance was confirmed in the 0.22 Hz regime for thrust

errors under 10% including varying V_{wo} . This was necessary as the system is non-linear and V_{wo} could have affected resonance. It was noted that the curve shifted and increased or decreased in magnitude slightly in each case. This is due to the non-linearity of the system equations and the variations in V_o during flight. The absolute case of no thrust showed resonance at 10000 feet with a maximum angle of attack of 1.25 radians (72 degrees).

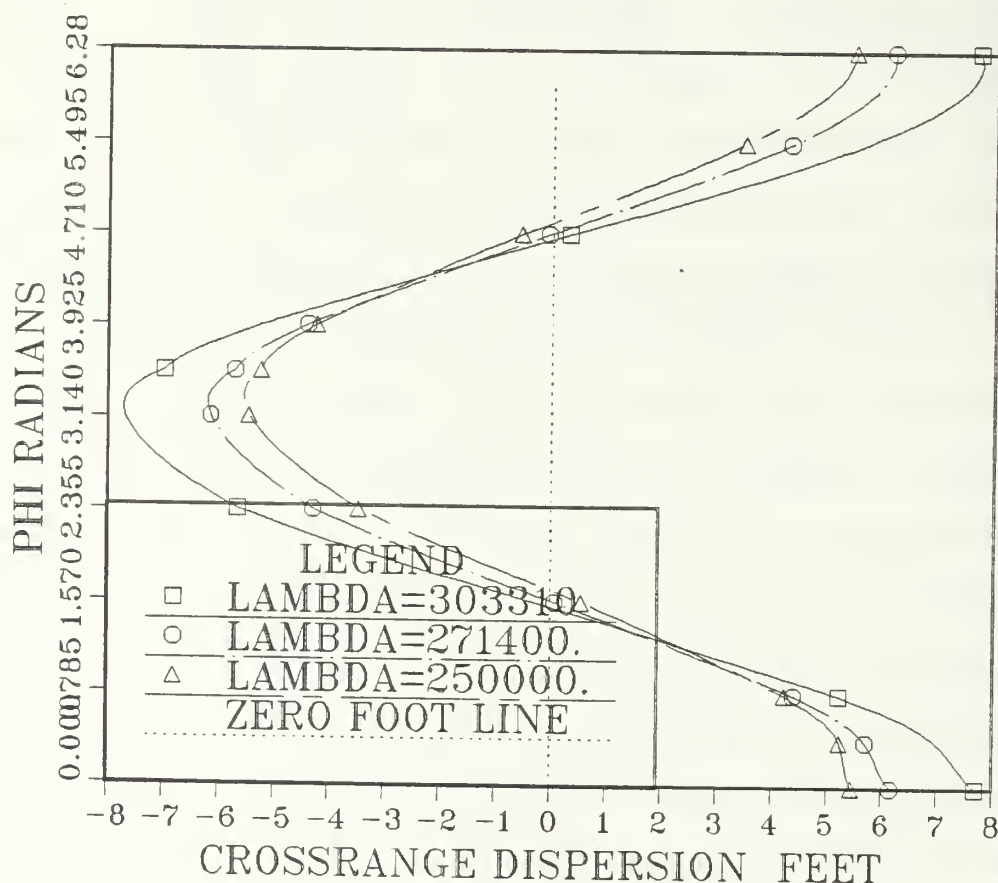


Figure 3-11 Dispersion Versus Wind Phase Angle (Large Lambda)

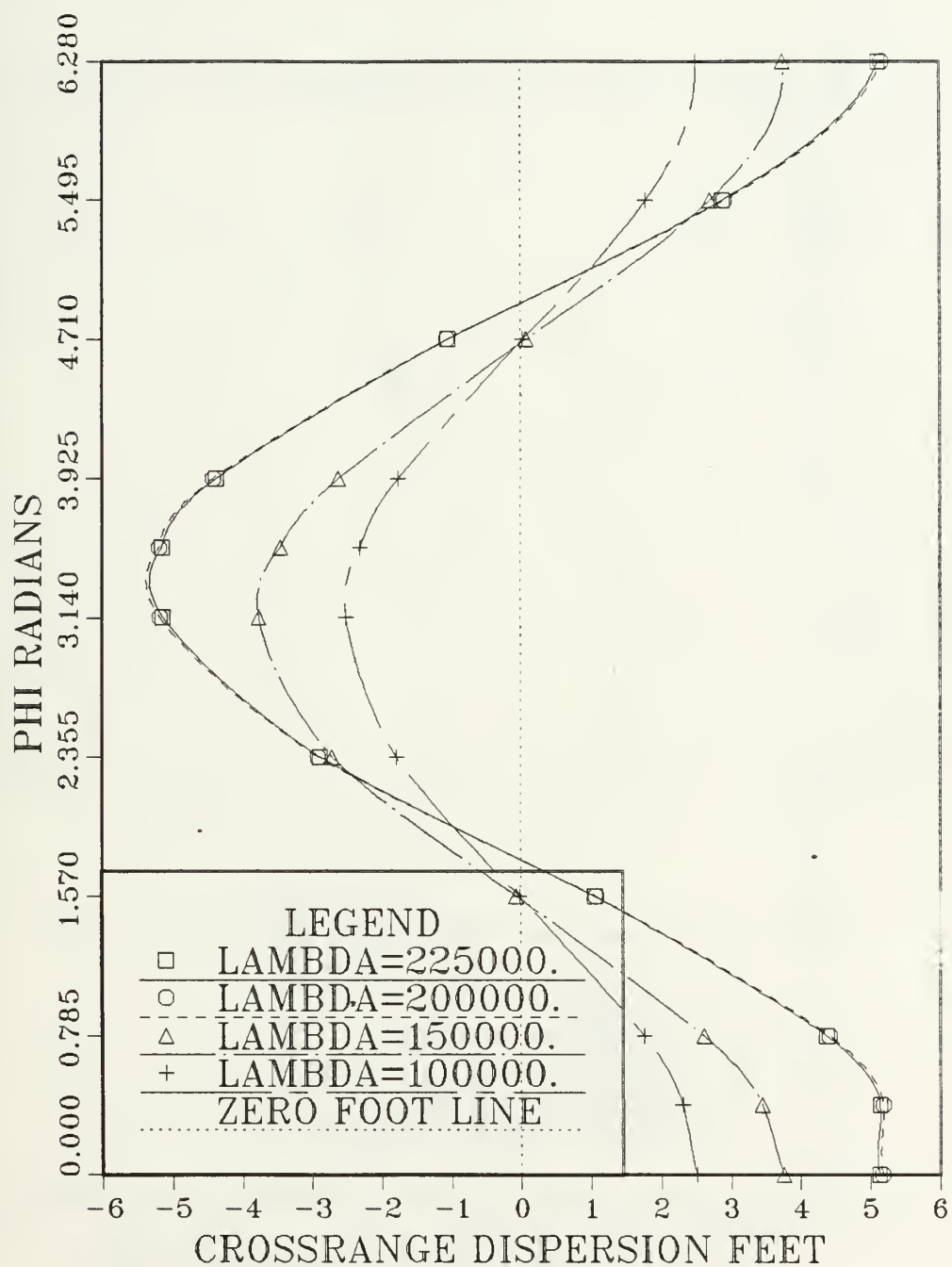


Figure 3-12 Dispersion Versus Phase Angle
(Medium Lambda)

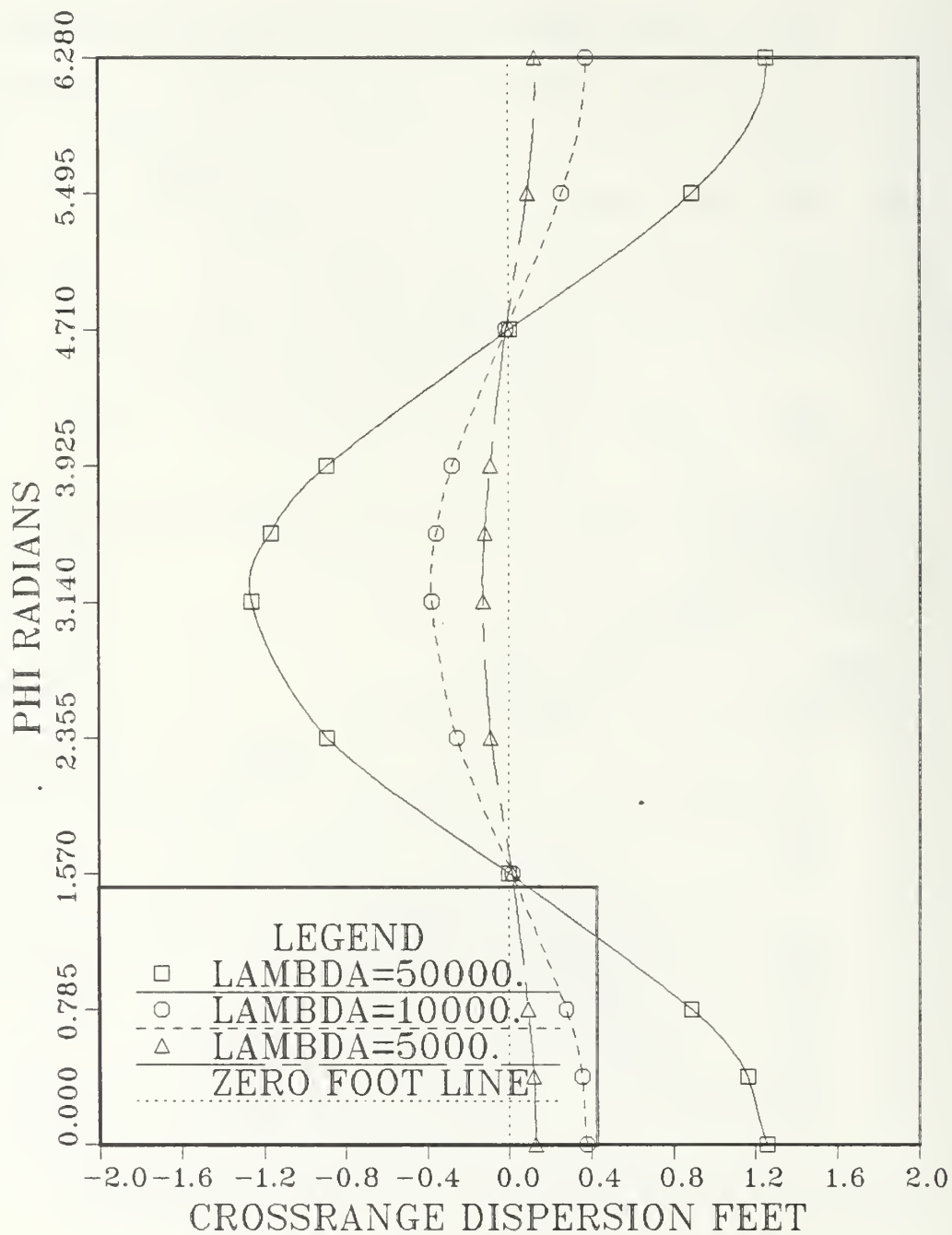


Figure 3-13 Dispersion Versus Phase Angle(Small Lambda)

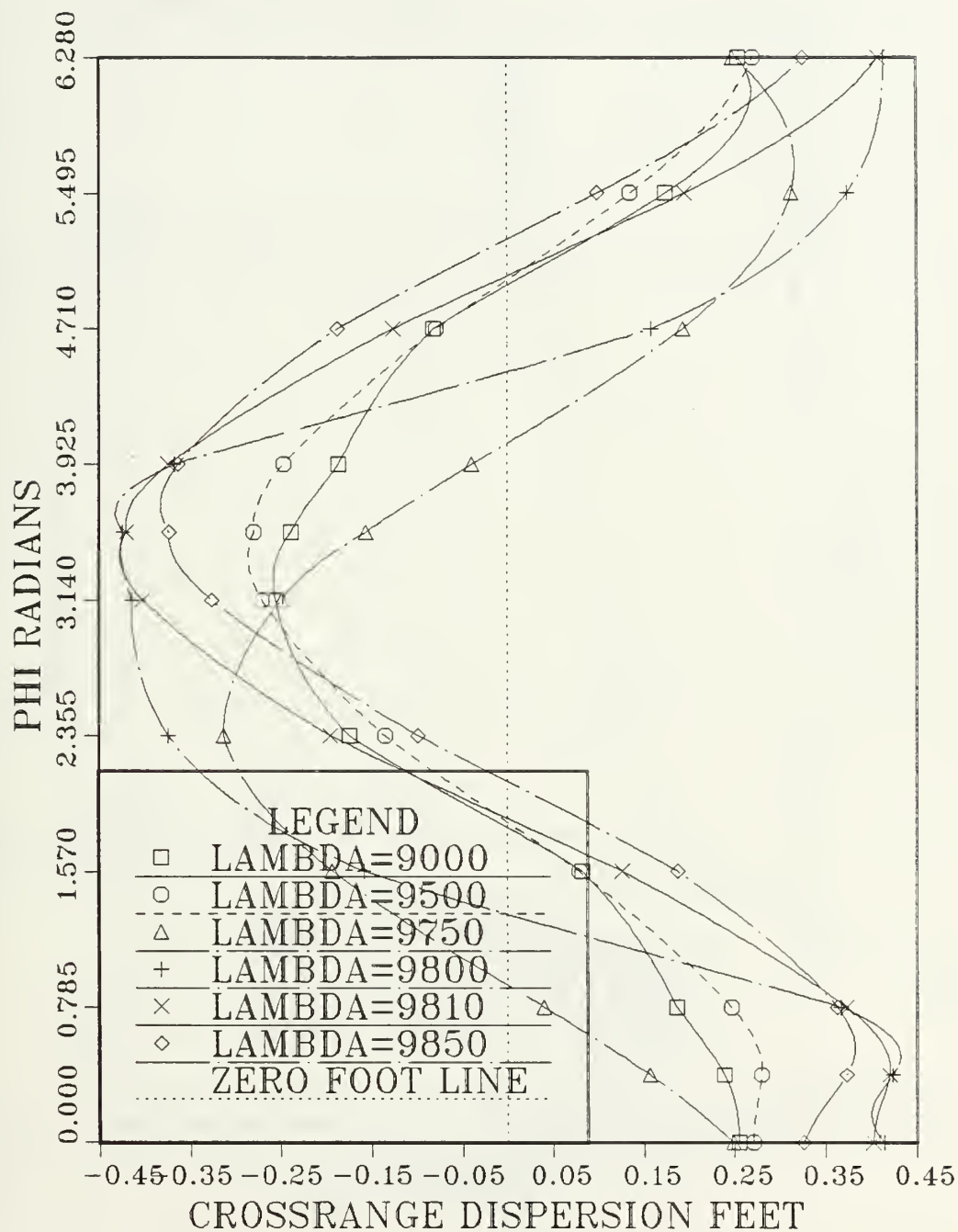


Figure 3-14 Dispersion Versus Phase Angle
Resonance Lambda

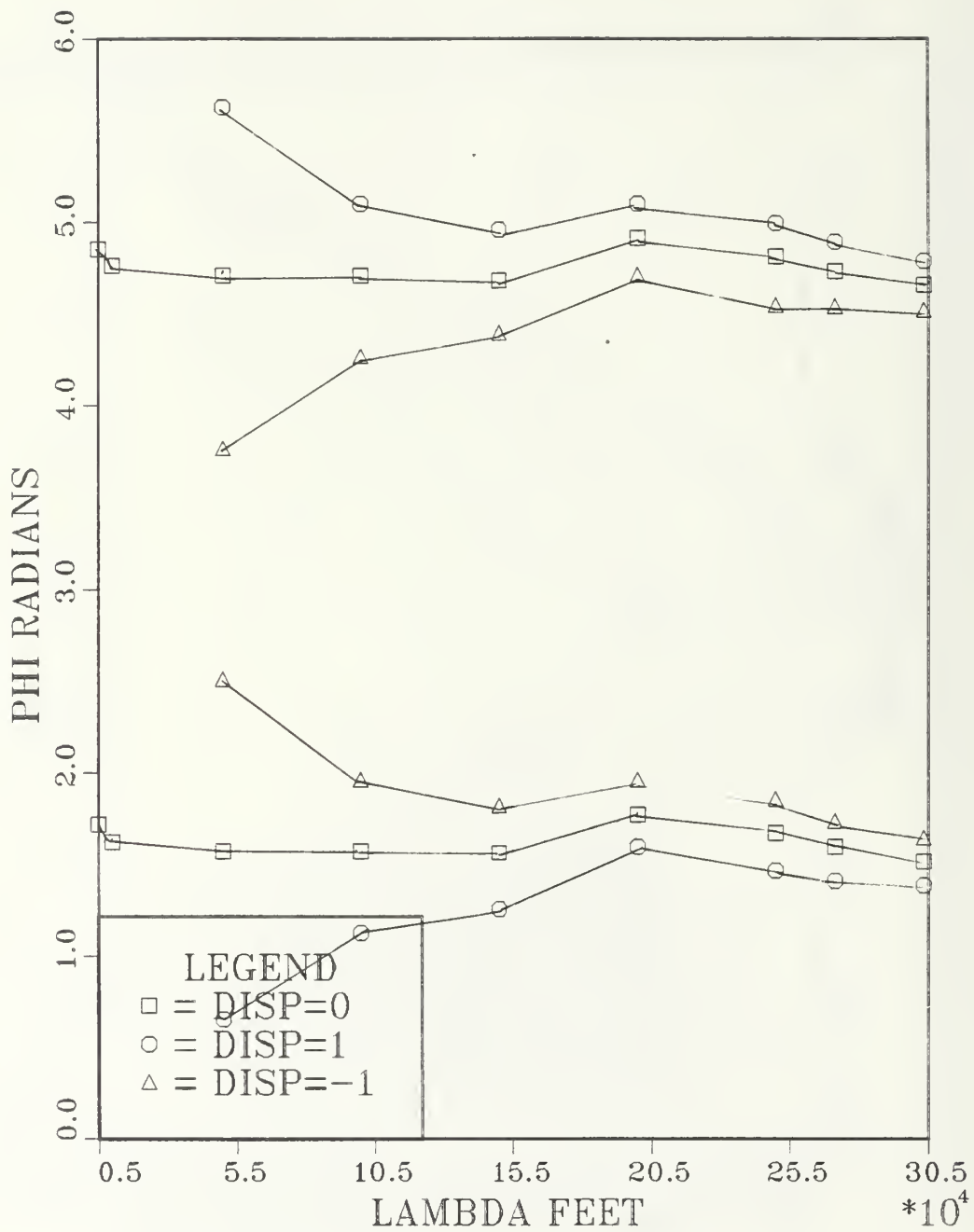


Figure 3-15 Phase Angle Versus Wavelength

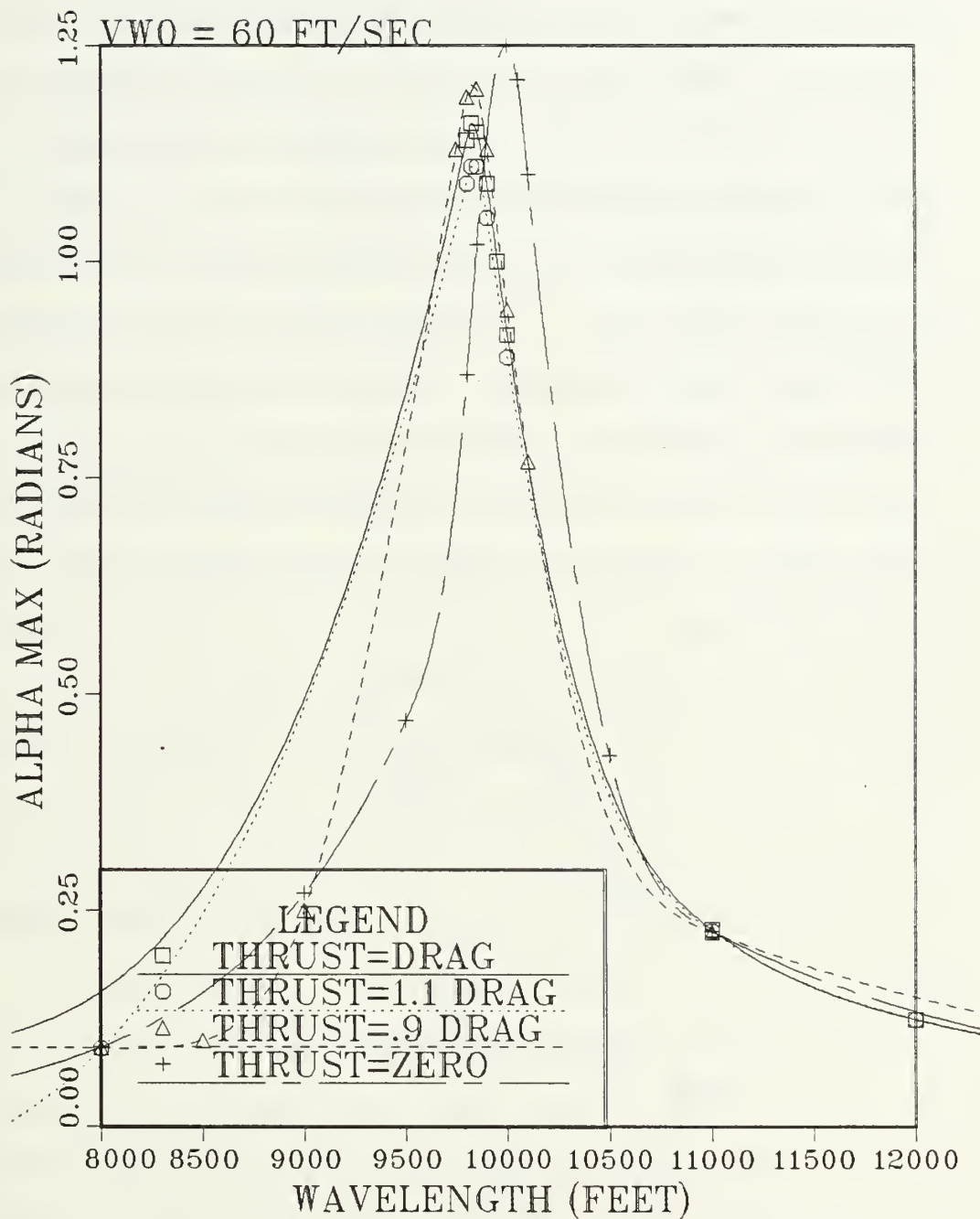


Figure 3-16 Detrimental Resonance Between Projectile
Short Period and Spatial Frequency of
Wind Profile

It is clear that if the wind profile experienced by the projectile has harmonic content near the natural frequency then the round will be unstable and/or have large dispersion at burnout. This is best illustrated by viewing the wind as $V_w(t)$ with reference to the projectile. By a Fourier transform of the wind profile resonance with projectile natural frequency (f_n) will be evident in the frequency domain. The wind oscillations need only be velocity variations with the appropriate harmonic content. Figure 3-17, which illustrates this concept, shows f_n coinciding with a maximum of $V_w(f)$. One would anticipate stability problems for this case.

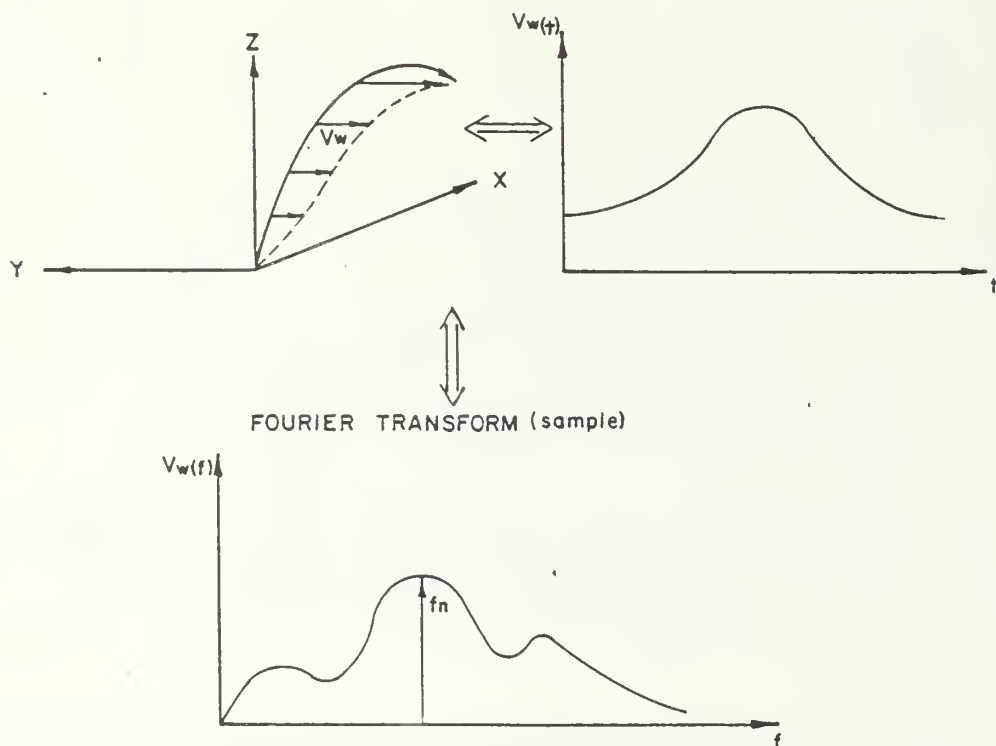


Figure 3-17 Fourier Transform Of Wind Profile Concept

Calculations for the long period resonance or phugoid show that the phugoid is irrelevant as flight time is too short:

$$T=4.44*V_o/g=301.8 \text{ seconds [Reference 3]}$$

The results of the sinusoidal winds were also compared with the aerodynamic jump phenomenon outlined in BRL report 1077 [Reference 4]. At first glance the sinusoidal wind results appear consistent with aerogump, but detailed calculations show otherwise. The rate of change of initial angle of attack is critical to aerogump and is easily incorporated into the aerogump equation. The results for the sine wind are a function of wavelength and of the same form as the simplified model results but the cosine wind and constant wind both yielded a small aerogump proportional to the initial wind. The magnitudes of the aerogump dispersions were more consistent with the net lift transient effects. Further, continuous perturbations in the form of wind after time zero are not in the aerogump equations and for all practical purposes the phenomenon is not observed in the model. These results should have been apparent before calculations were performed. Aerogump equations are not appropriate for non-zero wind conditions. Clearly, when wind is included the aerogump equations cannot predict dispersion.

B. FIVE DEGREES OF FREEDOM

As previously stated dispersion was measured from the ideal pseudo-vacuum trajectory at a fixed time for initiation of terminal guidance (T_c) 101 seconds. Thrust error sensitivity in the zero wind condition is presented in Figures 3-18 and 3-19. In these two figures it is clear that thrust errors can have a significant impact on the location of the projectile at the T_c . Figure 3-18 indicates that as thrust increases the dispersion moves downrange as expected. Figure 3-19 shows that as thrust increases the height of the projectile at T_c decreases. Due to added thrust the projectile is located at a point further along the parabolic trajectory; hence the height is less.

As well Figure 3-20 shows these effects on available burn time of the ramjet. For thrust equals drag burnout at 101 seconds exactly equals the T_c . With less thrust, terminal guidance is initiated before all the propellant is burned. Conversely, when thrust exceeds drag, burnout occurs prior to initiation of terminal guidance. Assuming this fixed time for initiation of terminal guidance, the projectile may experience up to seven seconds of unpowered flight (7% error) before the guidance is deployed. The period of unpowered flight with associated high drag will cause major dispersions as shown in subsequent figures.

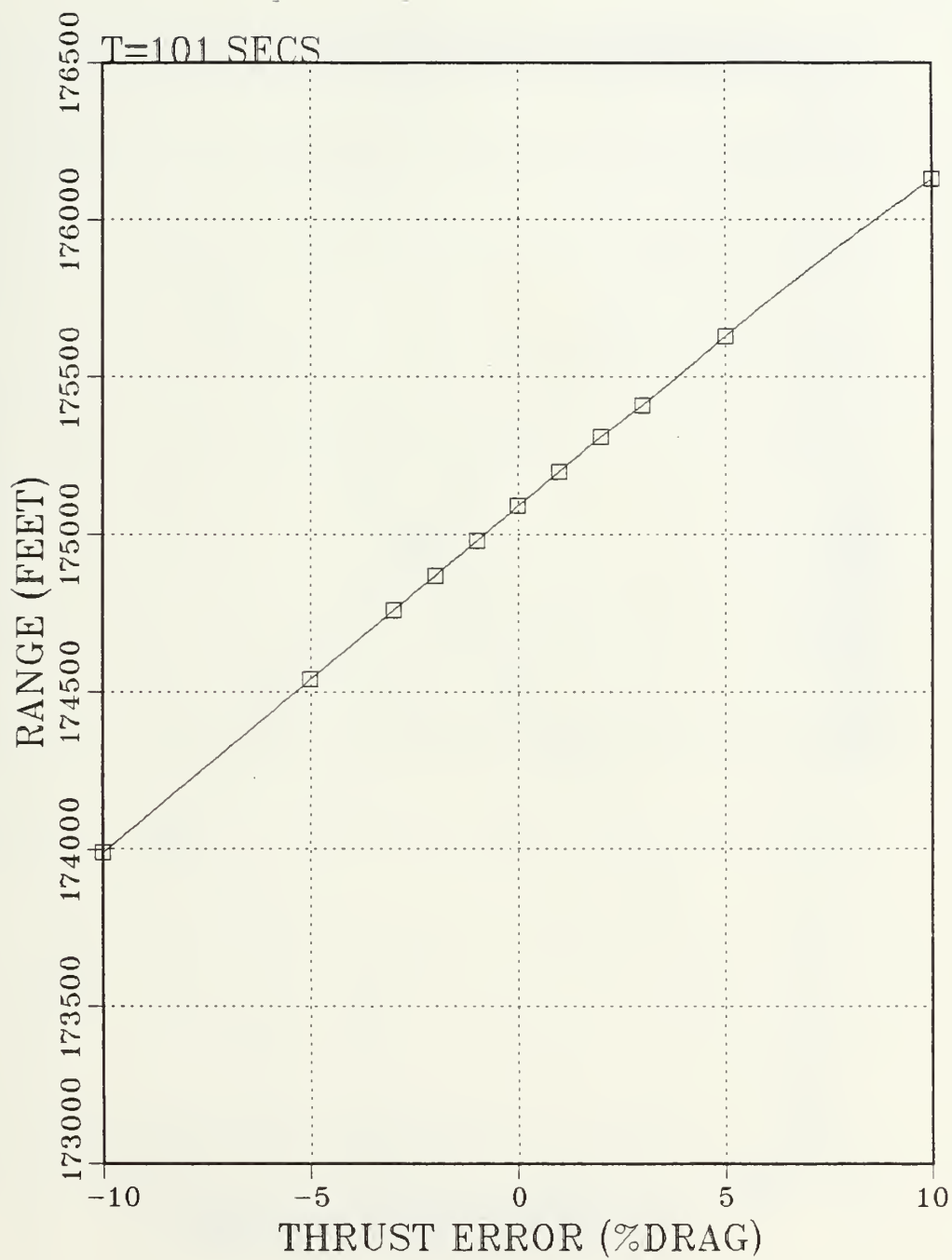


Figure 3-18 Thrust Error Effects (Range)

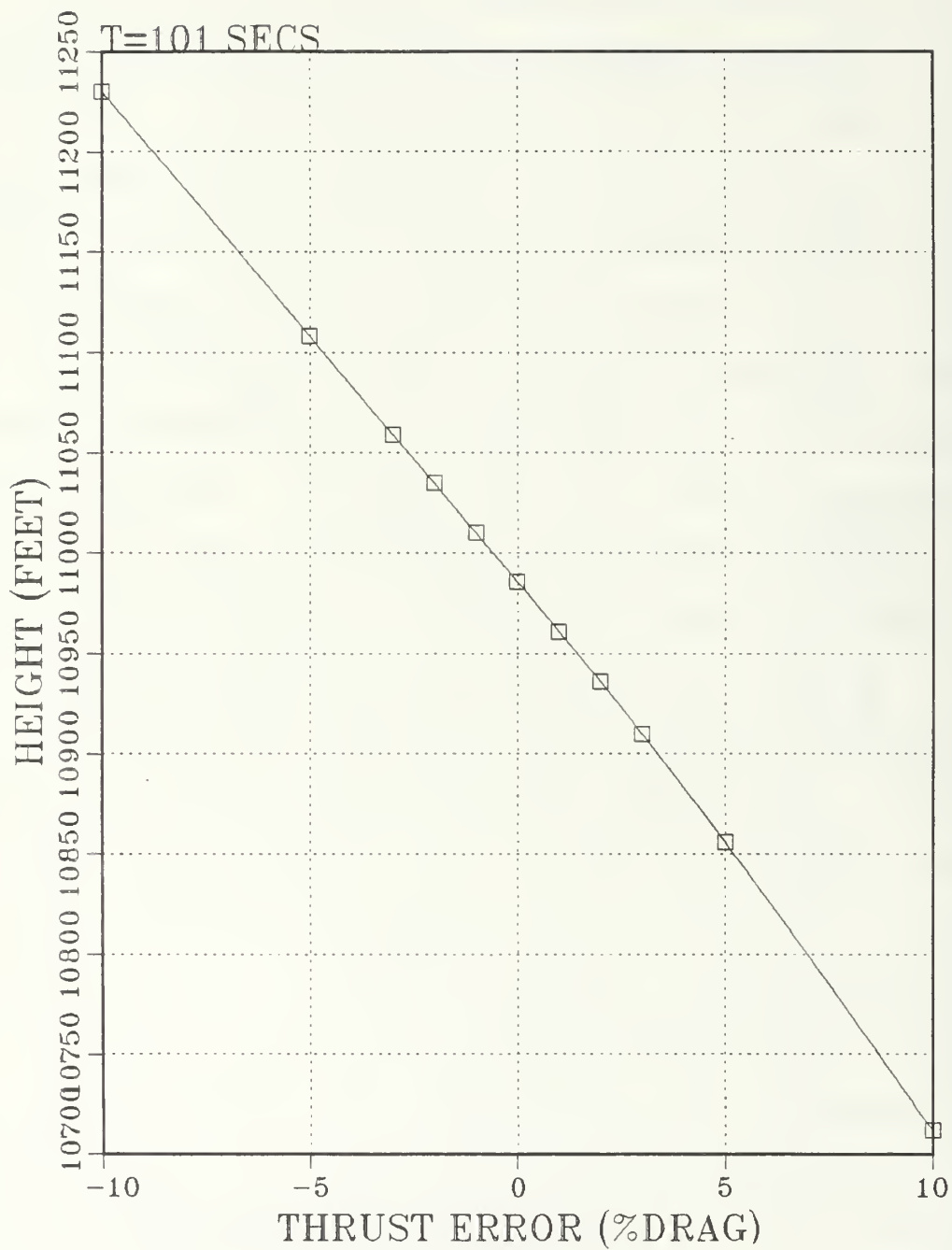


Figure 3-19 Thrust Error Effects (Height)

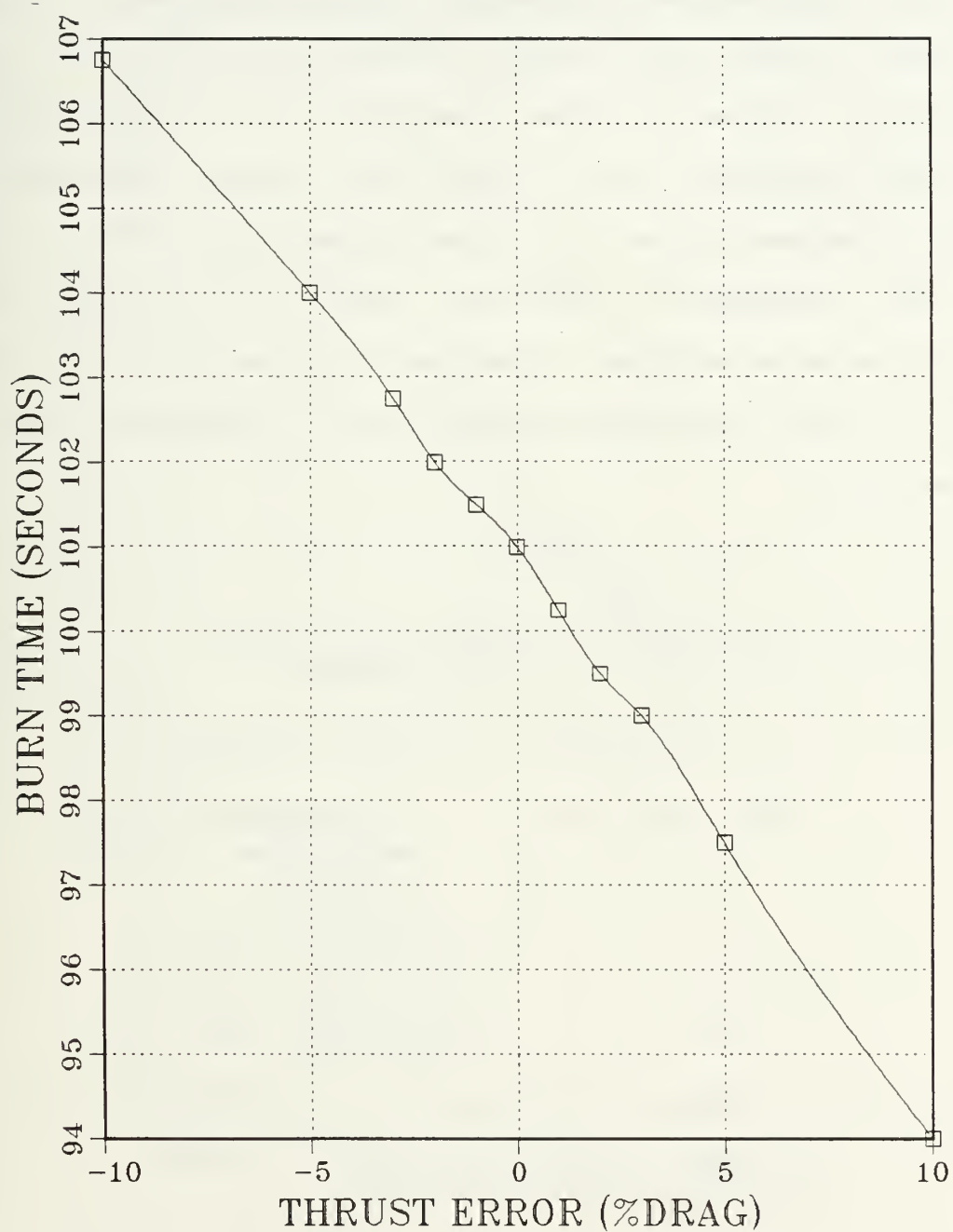


Figure 3-20 Thrust Error Effects (Burn Time)

Crosswind sensitivity results were very much the same as the three degree simulation. In fact the results appear even more linear with the same rotation about the zero zero point as in Figure 3-21. The gross features of Figure 3-3 and 3-21 are identical but Figure 3-3 shows dispersion at burnout whereas Figure 3-21 shows dispersion at T_c .

The crossrange dispersion results of a no thrust projectile with constant crosswind profiles and with thrust equal to drag (transients effects) are at Tables 3.3 and 3.4 respectively.

Table 3.3 No Thrust Wind Effects
Five Degrees

Thrust =0 time=101 seconds	
Vwxy(feet/sec)	dispersion (feet) crossrange
0	0
30	92.51
60	185.11
90	272.90
120	370.97

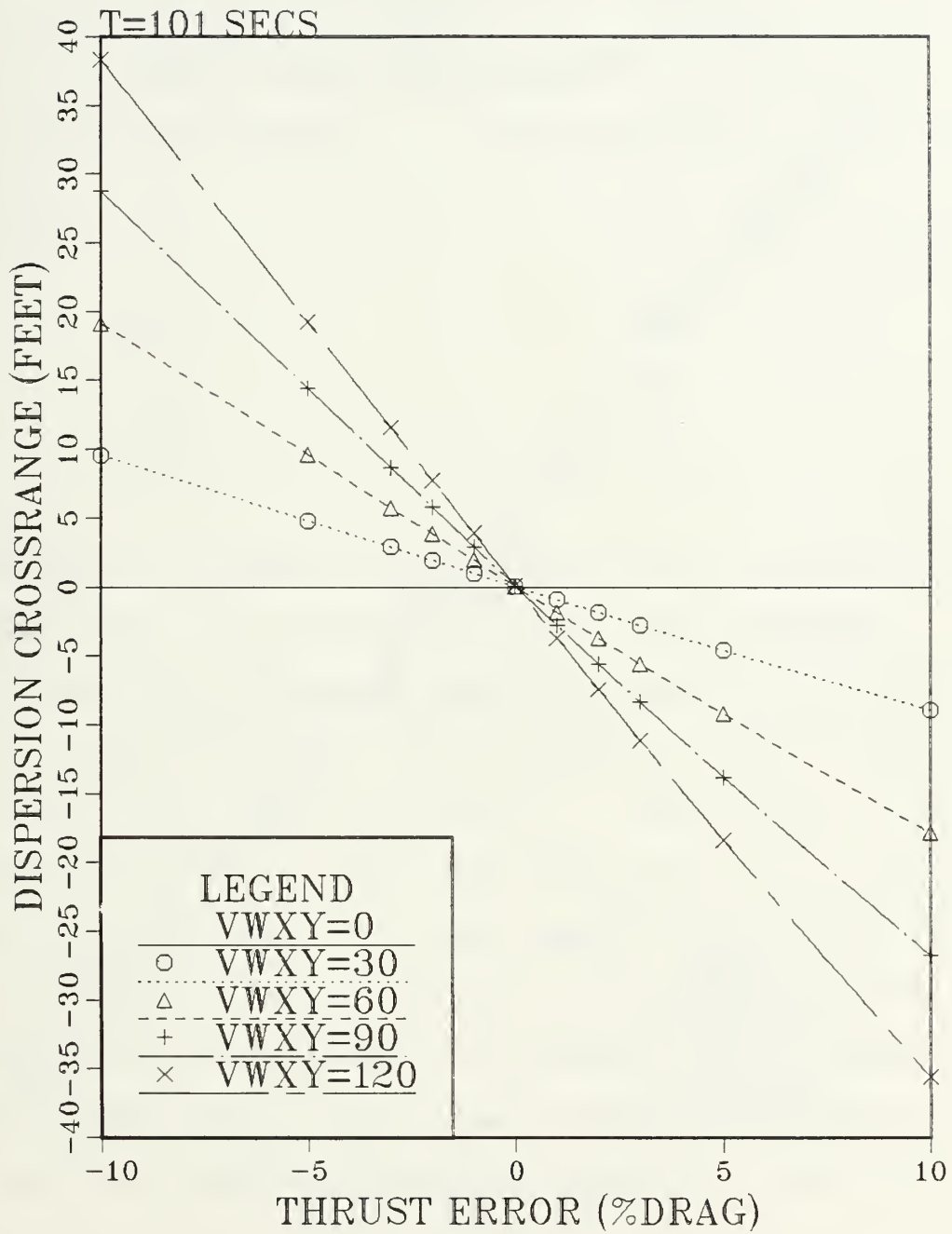


Figure 3-21 Crosswind Effects Five Degrees

Table 3.4 Dispersion Due to Net Lift
from Transients

Thrust=drag time=101 secs

Vwxy(feet/sec)	dispersion(feet)
0	0
30	.0202
60	.0413
90	.0643
120	.0919

Burn time was not significantly affected by crosswinds.

Headwind and tailwind effects on range,height and burntime in different thrust scenarios are shown in Figures 3-22 to 3-26. It is clear that dispersion from the pseudo-vacuum trajectory is minimized when thrust nearly equals drag.It is also apparent that the overthrusted trajectories involve greater dispersion as burnout occurs prior to terminal guidance and unpowered flight occurs for some time dependent on the scenario.This same error is observed in the case of headwinds and is most clear in the Figures 3-22B to 3-25B about the thrust equal to drag axis. (Note that Figure 3-22 to 3-25 inclusive have A,B and C sub-figures which are simply enlargements of key portions of the respective main figure).

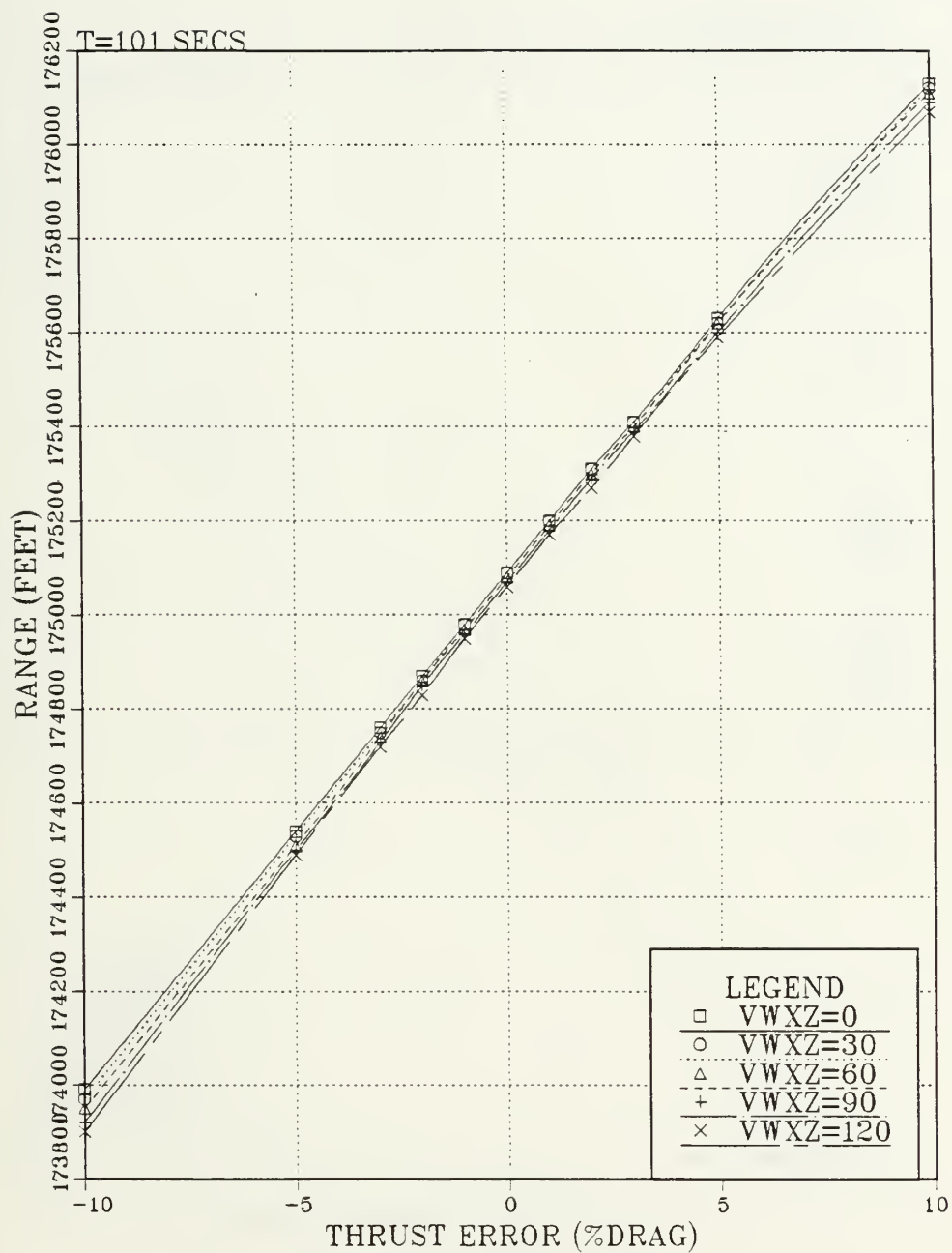


Figure 3-22 Headwind Sensitivity (Range)

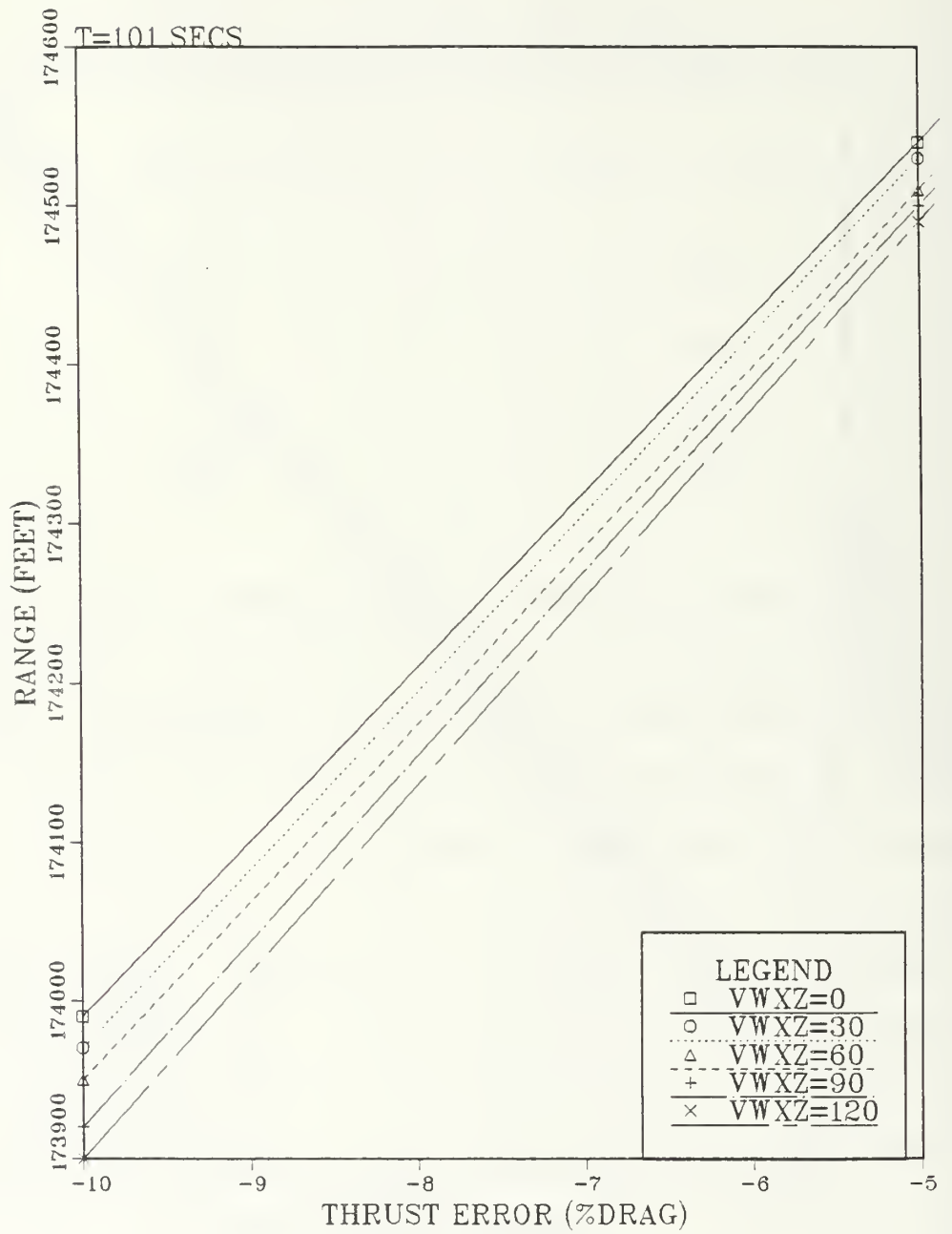


Figure 3-22A Headwind Sensitivity (Range)

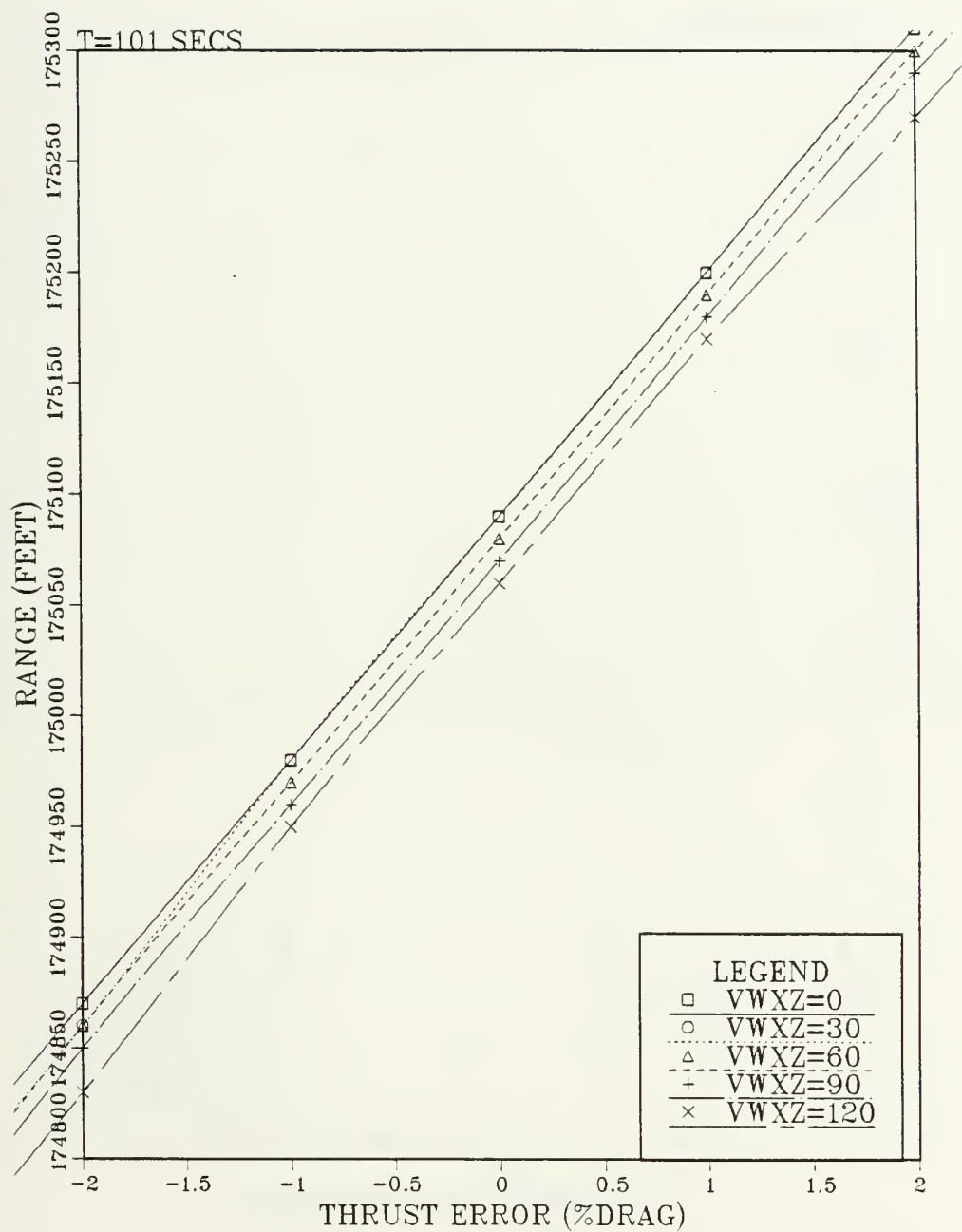


Figure 3-22B Headwind Sensitivity (Range)

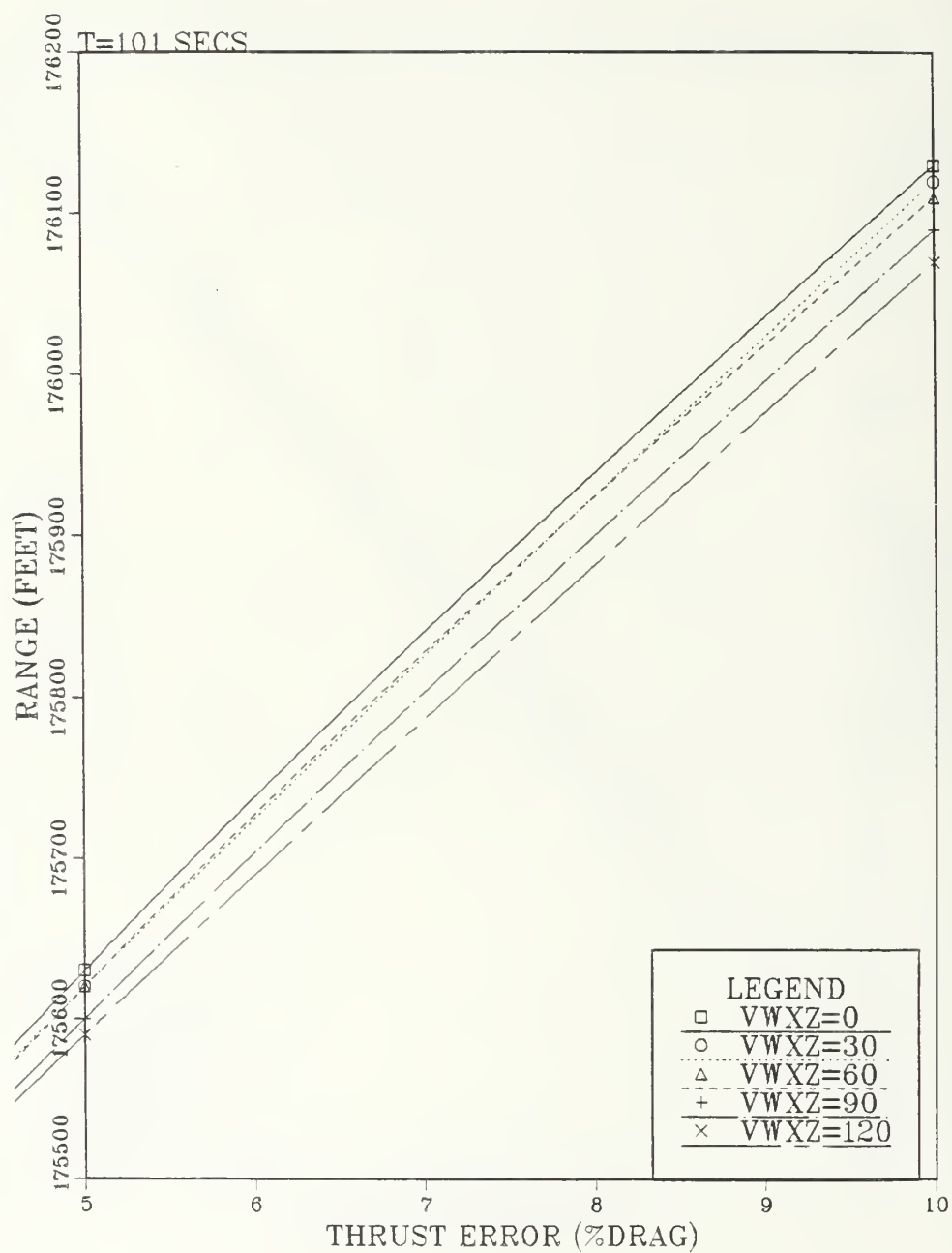


Figure 3-22C Headwind Sensitivity (Range)

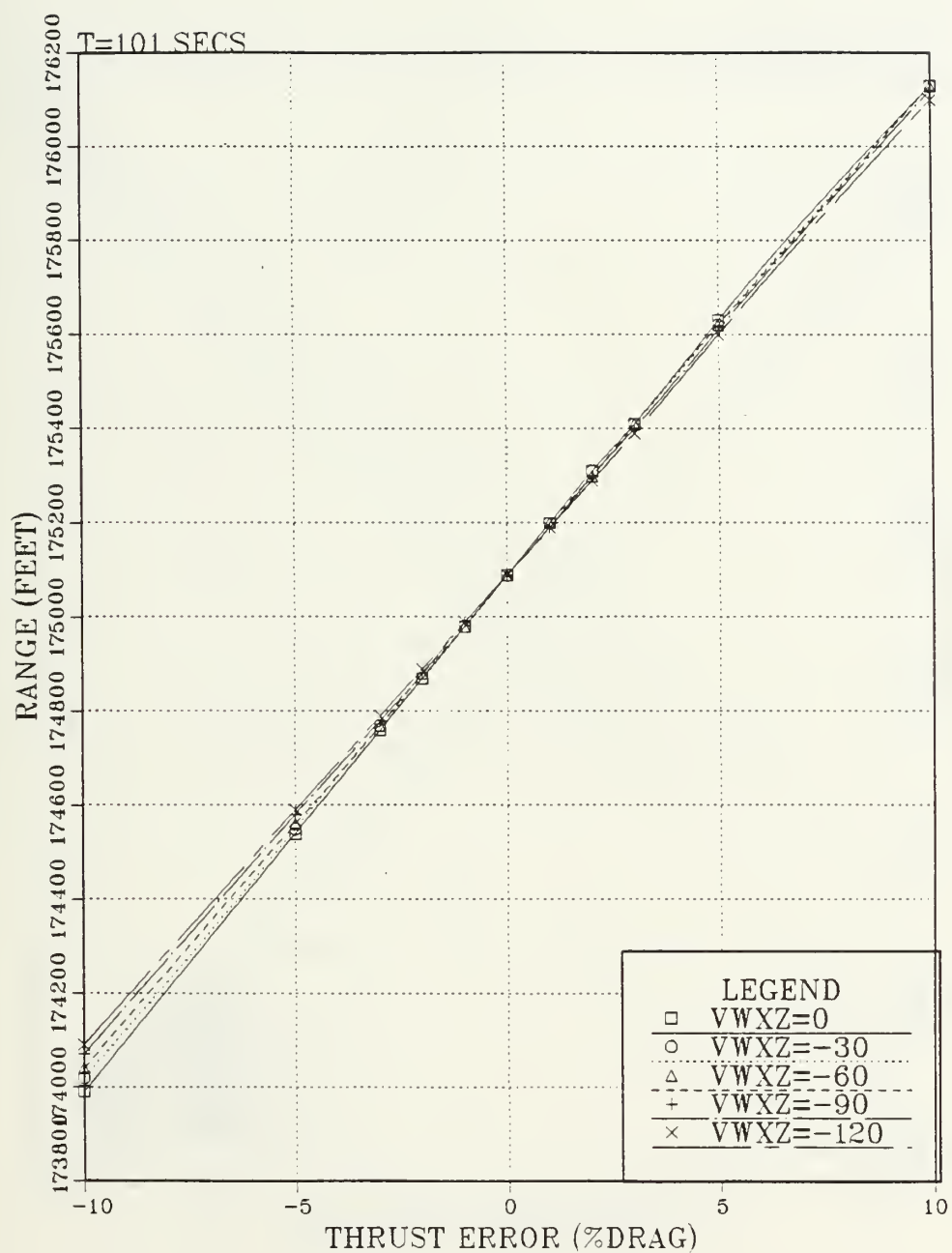


Figure 3-23 Tailwind Sensitivity (Range)

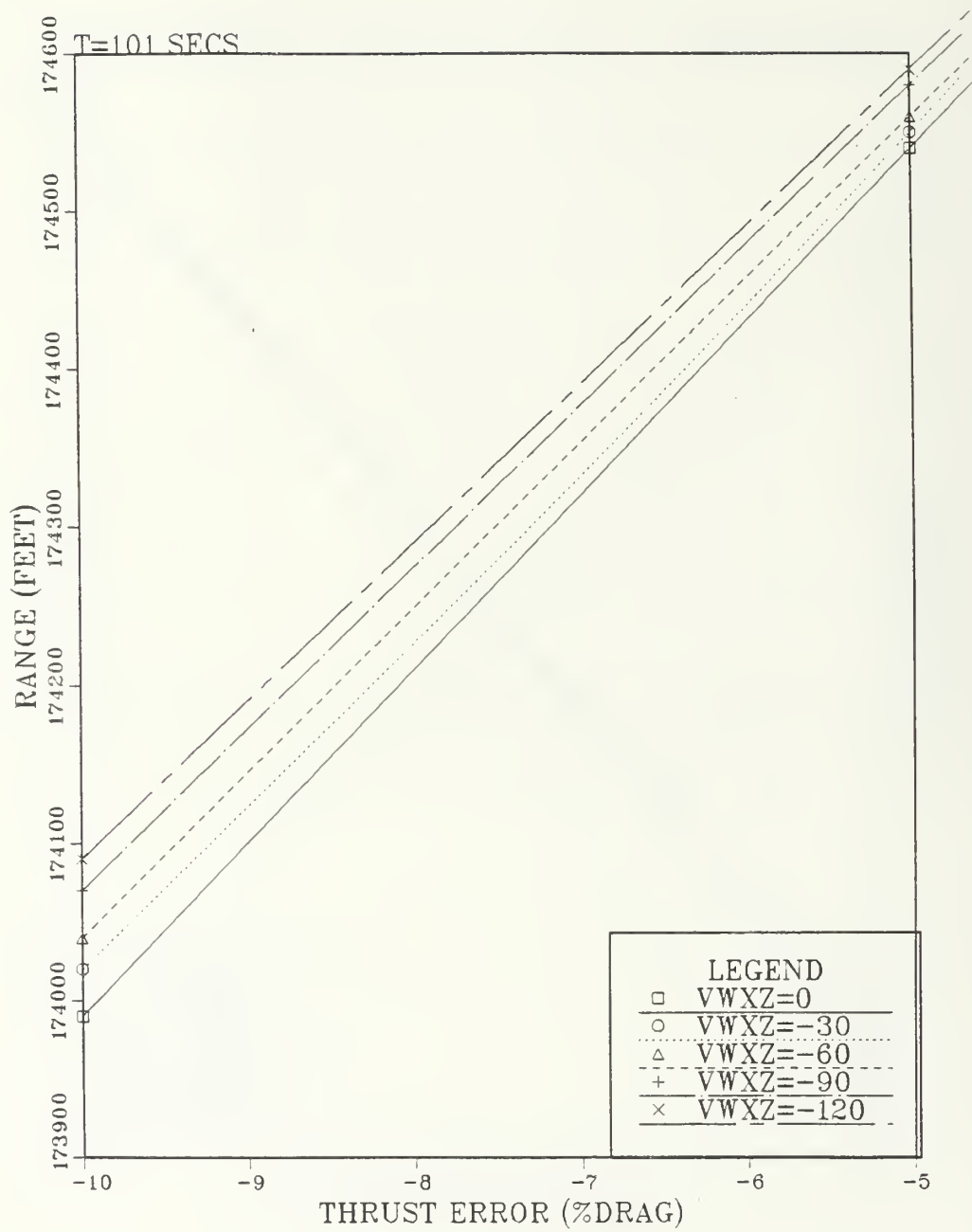


Figure 3-23A Tailwind Sensitivity (Range)

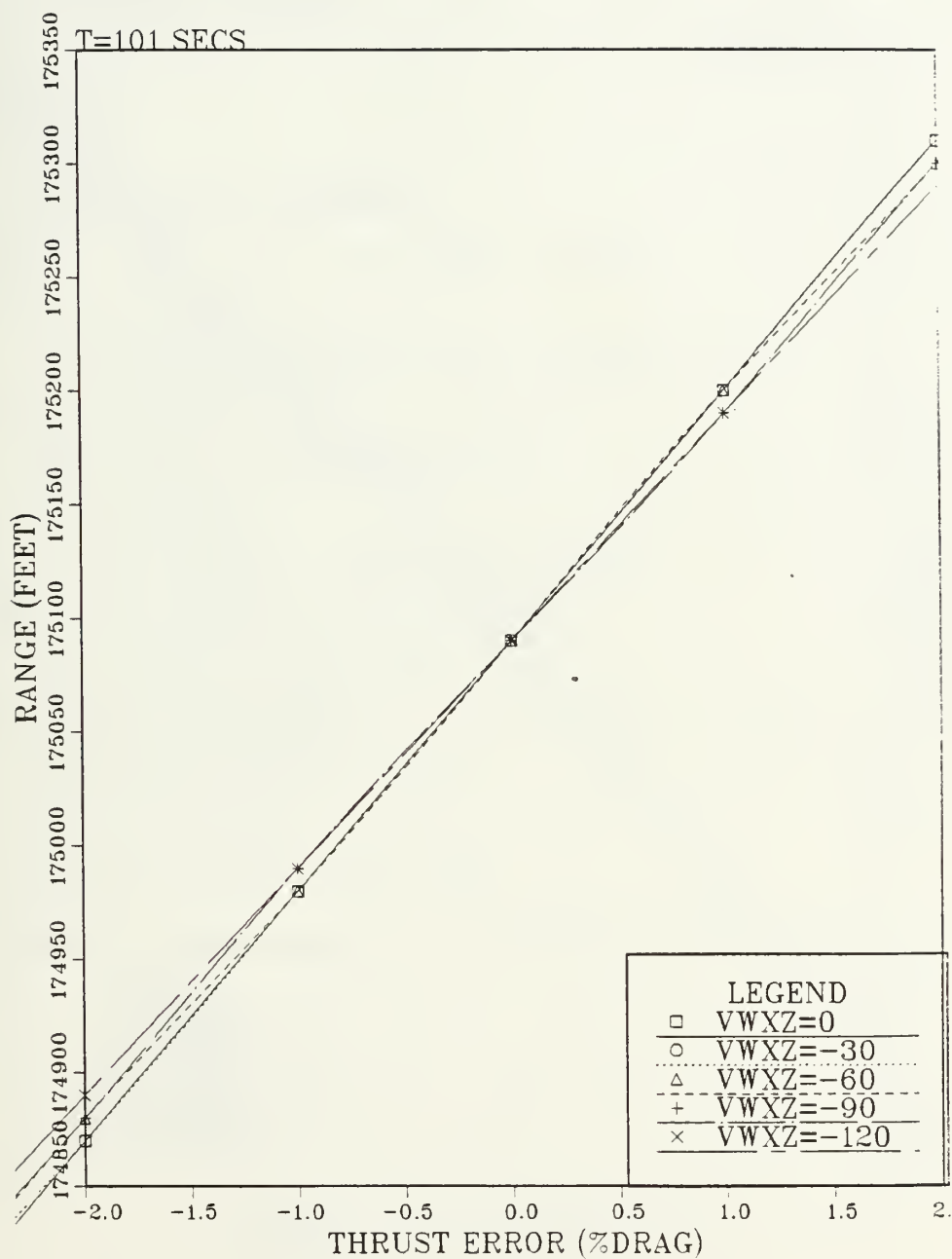


Figure 3-23B Tailwind Sensitivity (Range)

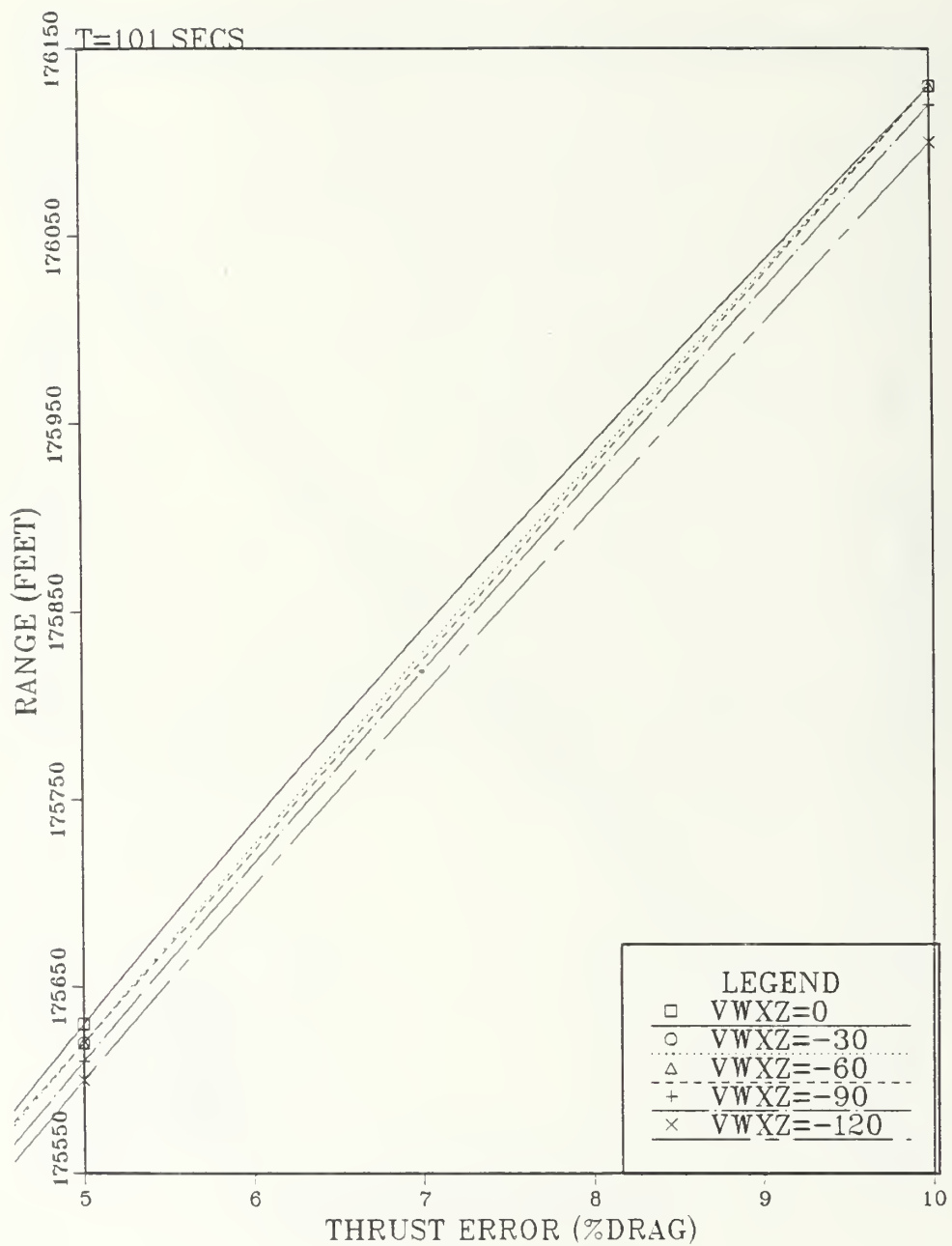


Figure 3-23C Tailwind Sensitivity (Range)

APPENDIX D PSEUDO-VACUUM TRAJECTORY PROGRAM

```

10 DIM X(300),Y(300),RO(300),D(300),MDOT(300),M(300),V(300)
12 DIM CDO(300),MA(300)
15 DIM T(300)
20 MMIN=198
30 ISP=950
40 DELT=.5
50 M(1)=225
60 THETA=.7853981634000006#
70 VO=2452
75 LPRINT "TIME","X","Y","MASS","SPEED"
80 FOR I=1 TO 300
90   X(I)=VO*COS(THETA)*T(I)
100  Y(I)=(VO*SIN(THETA)*T(I))-(16.087*T(I)^2)
110  V(I)=((VO*COS(THETA))^2+(VO*SIN(THETA)-
      32.174*T(I))^2)^.5
120  TEMP =518.688-.0035662*Y(I)
150  RO(I)=(2116.22*(1-(.0035662*Y(I)/518.688))^5.256)/
      (1716.5*TEMP)
155  IF Y(I)>=36089! THEN RO(I)=.001271
157  IF Y(I)>=36089! THEN TEMP=389.99
158  MA(I)=V(I)/SQR(1.4*1716.3*TEMP)
159  CDO(I)=.5015-.1025*MA(I)
160  D(I)=.276*.5*RO(I)*.3491*V(I)^2
161  D(I)=D(I)/.276*CDO(I)
170  MDOT(I+1)=D(I)/ISP
180  M(I+1)=M(I)-MDOT(I)*DELT
190  T(I+1)=T(I)+DELT
195  LPRINT T(I),X(I),Y(I),M(I),V(I)
200  IF M(I+1)<=MMIN GOTO 220
210 NEXT I
220  LPRINT "RAMJET BURNOUT BETWEEN T=";T(I);"AND";T(I+1)

```

burning. Burnout will occur on the vacuum trajectory but not at the same point, as shown in Figure C-2.

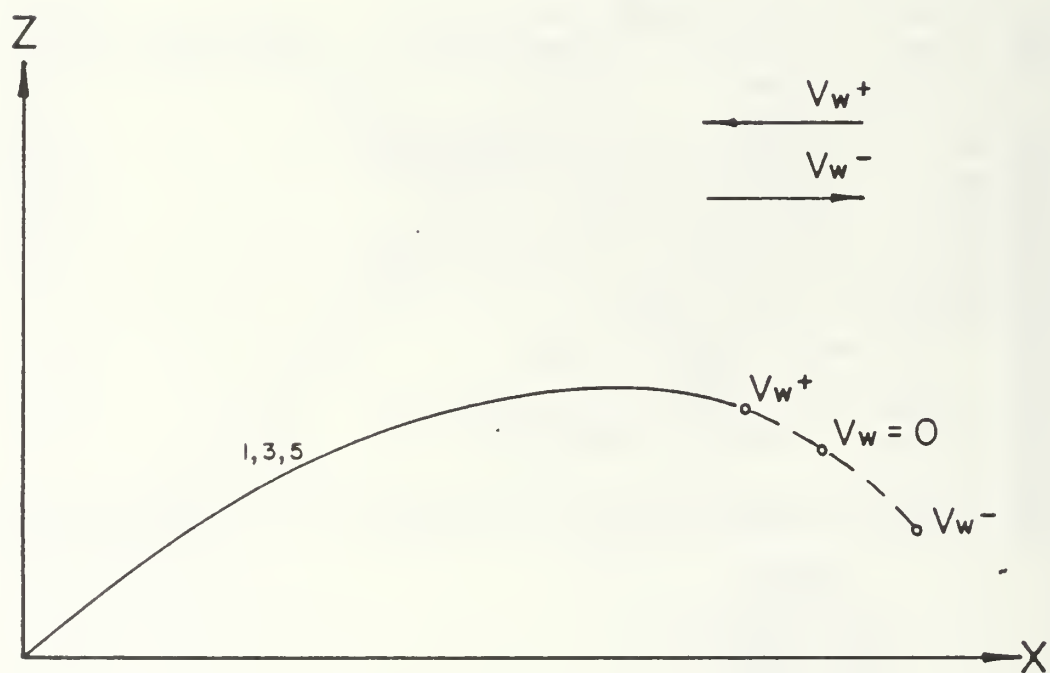


Figure C-2 Burnout Variations

In Figure C-1 wind (V_w) has been added for the curve #4 in the x direction. The new equations are :

$$m\ddot{x}_4 = (-D_x + D_w) + T_x$$

$$m\ddot{z}_4 = -D_z + T_z - mg$$

where $D_x + D_w = 1/2 \rho U_x^2 C_d A$

and U_x (wind relative to the projectile) $= V_x + V_w$. With no thrust curve 4 results.

Finally, if thrust is added to equal drag the following equations are valid:

$$m\ddot{x}_5 = 0 \text{ or } T_x = D_x + D_w$$

$$m\ddot{z}_5 = -mg \text{ or } T_z = D_z$$

The accelerometer(s) read the acceleration caused by any differences in the thrust and drag forces (zero in this case).

It is clear that curves 1 and 5 are equal (and 3 if thrust=drag) but the burntime of a ramjet will not be equal in each case due to different drag profiles.

$$t = (\text{mass fuel})(I_{sp})/\text{thrust}$$

Therefore headwinds will require more thrust and burntime will be shorter. Conversely tailwinds allow longer

case $U_x=V_x$ and $U_z=V_z$. This trajectory is represented by curve 2. An accelerometer in the x direction measures D_x/m and D_z/m in the z direction.

If thrust is added, the trajectory is as shown at curve 3 (thrust greater than drag). The key equations are then:

$$m\ddot{x}_3 = -D_x + T_x$$

$$m\ddot{z}_3 = -D_z + T_z - mg$$

Accelerometers would measure $(T_x - D_x)/m$ and $(T_z - D_z)/m$ respectively. If thrust equals drag the trajectory would be curve 1.

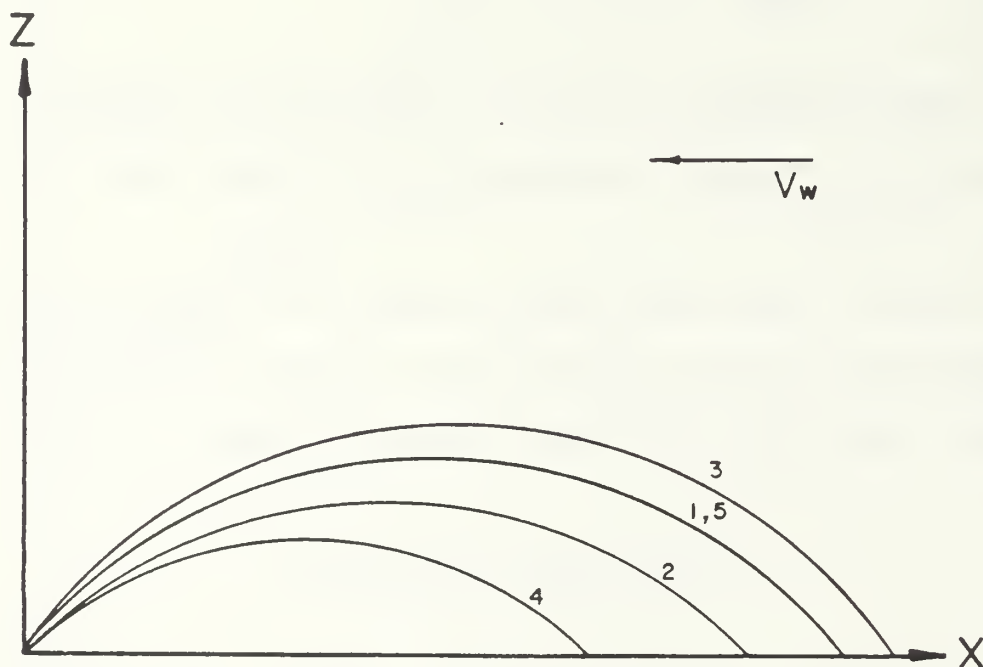


Figure C-1 Pseudo-Vacuum Trajectory Concept Curves

APPENDIX C-PSEUDO-VACUUM TRAJECTORY CONCEPT

The basic concepts behind the pseudo-vacuum are not always readily apparent. This appendix analyzes the basic equations of motion in the following sequence of cases to illustrate the concept:

vacuum trajectory

atmosphere trajectory

thrust trajectory

wind influenced trajectory

thrust equal drag trajectory

In Figure C-1 (curve 1) the applicable equations of motion are:

$$m\ddot{x}_1 = 0$$

$$m\ddot{z}_1 = -mg$$

An accelerometer on the projectile in the z direction would measure no acceleration as it is in free fall already. This is similar to a satellite orbit or someone on an elevator in free fall.

When atmosphere is added the key equations are:

$$m\ddot{x}_2 = -D_x = -1/2 \rho U_x^2 A C_d$$

$$m\ddot{z}_2 = -D_z - mg$$

where U is relative wind and D is atmospheric drag. In this

When $t=0$, the equation reduces to:

$-2\delta w + 1(2\delta w) = 0$ which is expected if the initial condition is zero. (ie. dispersion at zero equals zero at time zero).

As t approaches infinity the equation value approaches infinite dispersion, but the oscillations of α have damped out. Note that the first derivative, proportional to velocity, tends to a constant value:

$(w/(\delta^2 + w^2))/m$ as t approaches infinity which is also to be expected.

APPENDIX B TRANSIENT ANGLE OF ATTACK CALCULATIONS

The following equation of motion applies to the dynamics of angle of attack (α) oscillations due to the torque equation described in the three-degrees-of-freedom model.

$$m\ddot{y} = Lw \text{ which is proportional to } \alpha(t)$$

where angle of attack is of the form :

$$\alpha(t) = e^{-\delta t} \sin(\omega t) \text{ where } \delta \text{ is the damping constant}$$

and ω is the angular velocity. Therefore:

$$\begin{aligned} m_y &= \int_0^t \int_0^T \alpha(t) dt dT \\ &= \int_0^t \int_0^T e^{-\delta t} \sin(\omega t) dt dT \\ &= \int_0^t \left[\frac{e^{-\delta T} (-\delta \sin(\omega T) - \omega \cos(\omega T)) + \omega}{\delta^2 + \omega^2} \right] dT \\ &= \frac{\left[\begin{aligned} &\omega t (\delta^2 + \omega^2) - 2\delta\omega + \\ &e^{-\delta t} (\delta^2 \sin(\omega t) + 2\delta\omega \cos(\omega t) - \omega^2 \sin(\omega t)) \end{aligned} \right]}{(\delta^2 + \omega^2)^2} \end{aligned}$$

impulse=950 "seconds"

Mass Property Equations:

$CG = (225 \times 39.4) - (52.0 \times \text{fuel burned}) / (225 - \text{fuel burned})$ in

$I_{zz} = .35 - (.0019 \times \text{fuel burned})$ in slug-ft

$I_{xx} = I_{yy} = 18.8 - (.0423 \times \text{fuel burned})$ in slug-ft

Aerodynamic Coefficient Equations:

$C_d = C_{d0} + .5 \times C_l \times \sin(\alpha)$

$C_{d0} = -.1025 \times MACH + .5015 \quad (1.8 < MACH < 2.2)$

$C_m = C_l (X_{cg} - X_{cp}) / d$

$C_l = C_{l_\alpha} \times \alpha$

Key Wind Tunnel Results (per degree):

MACH=1.8

$C_{d0} = .317 \quad C_{mq} = -203$

α	0	2	4	6	8	10
C_l	0	.18	.38	.62	.92	1.3
X_{cp}	45.4	45.6	48.2	49.7	50.2	50.0

MACH=2.2

$C_{d0} = .276 \quad C_{mq} = -190$

α	0	2	4	6	8	10
C_l	0	.19	.40	.65	.95	1.3
X_{cp}	42.9	42.9	44.6	45.1	46.0	44.6

$C_{mq} = d(C_m) / d(qd/2V)$

Initial Muzzle Spin Rate 30 PI radians /sec

APPENDIX A-PROJECTILE CHARACTERISTICS

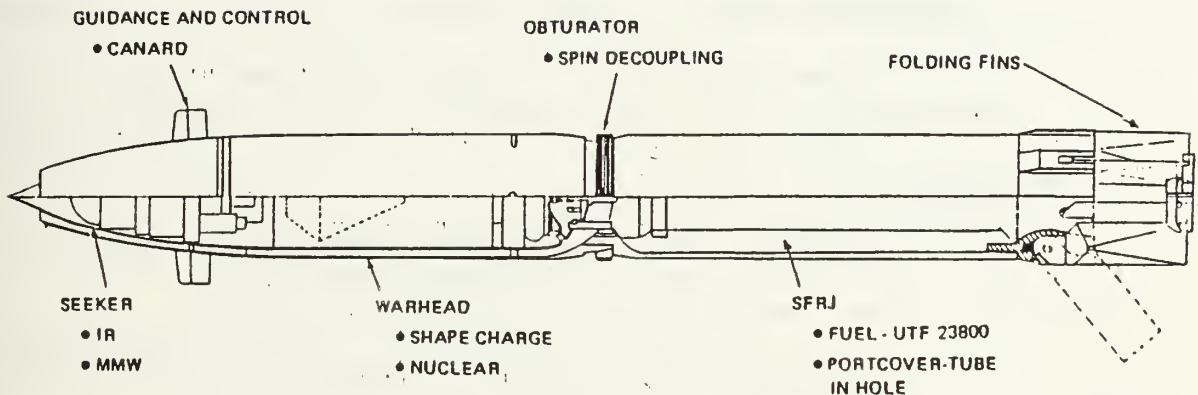


Figure A-1 ARMT Projectile Baseline Design

The following characteristics are obtained from References 2 and 6.

length=72 inches

diameter=8 inches

launch weight=225 lbm

launch CG=39.4 inches from spike apex

fuel weight=27 lbm (CG at 52.0 inches from apex)

except where harmonic content near resonance is contained in the wind profile.

-headwinds create greater dispersion as ramjet burnout occurs before terminal guidance is initiated. Crosswinds and tailwinds generally will have minimal effects.

Recommendations for further study related to this thesis are:

-Dynamics at launch including the initial spin damping, Magnus effects and aerodynamic jump.

-Dynamics at terminal guidance including air inlet spike ejection and canard deployment.

-Complete adaptation of BRL HTRAJ on the NPGS IBM system to use non-linear aerodynamics.

IV. CONCLUSIONS

Generally this thesis confirms the viability of the pseudo-vacuum trajectory from a thrust equals drag projectile. Indeed winds up to 120 feet per second and thrust errors up to five percent created dispersions of less than 600 feet over a range of 175090 feet for the ARMT projectile.

Specifically the following conclusions are made:

- the drag due to wind (D_w) is the aerodynamic force which creates the most dispersion.

- the net lift due to transients (L_w) is a minor aerodynamic force in creating dispersion.

- the dispersion is proportional to the damping coefficient (C_{mq}), although for practical values of C_{mq} dispersion can be treated as insensitive to C_{mq} .

- the projectile resonance or short period is at approximately 0.22 Hz and is unstable in the resonance regime due to variable wind profiles. The phugoid is irrelevant.

- thrust errors are the most significant errors contributing to dispersion.

- winds have a minor effect on dispersion during powered flight when thrust approximates drag,

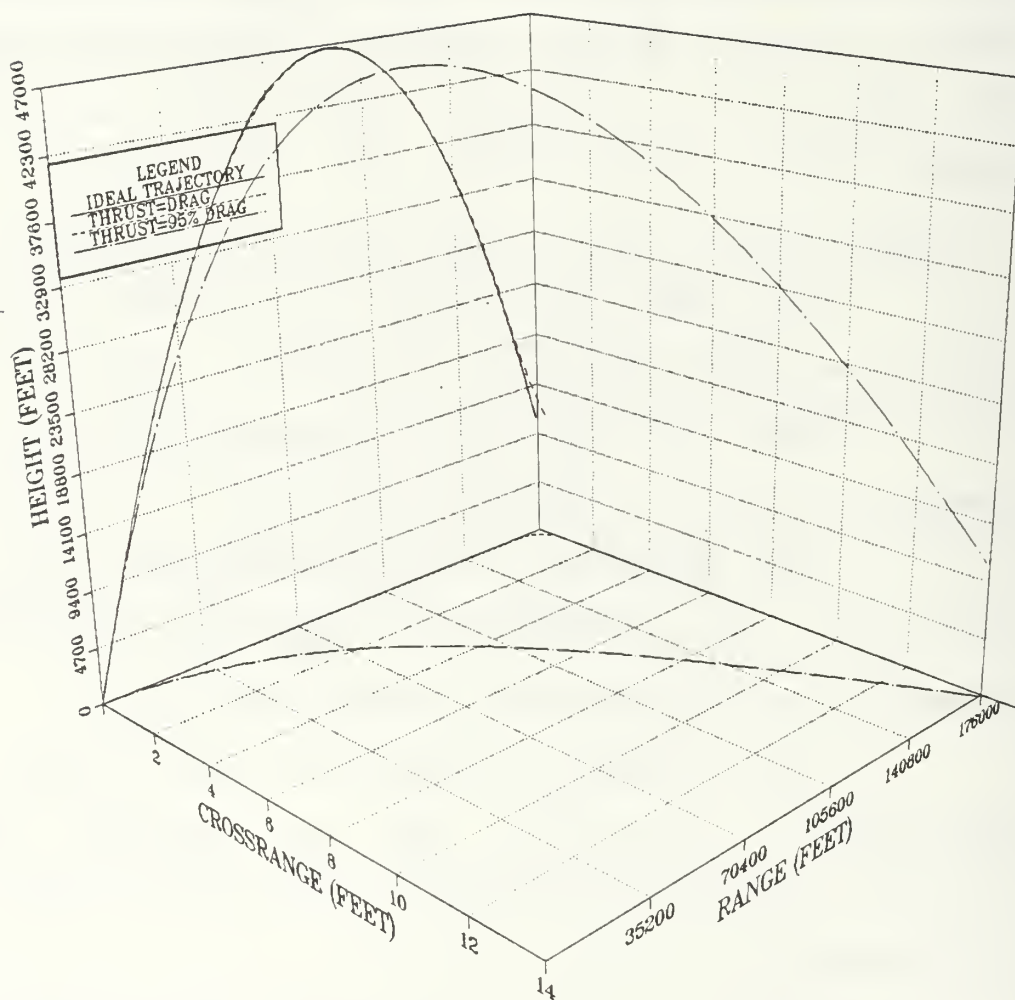


Figure 3-28 Three Dimensional Trajectory With Altitude Dependent Wind Profile

Wind effects during near thrust equals drag portions of the trajectory were very small. The critical factor affecting the dispersion will be the setting of the terminal guidance clock in the projectile. This presents several options for setting initiation of terminal guidance:

- Fixed time irrespective of trajectory (ie. elevation of gun). Burn time would be shorter at less than 45 degree launch and the basket would be more sensitive to wind and thrust errors. As well the trajectory would change and so would the predicted basket.

- Fixed time for a given trajectory. This requires analysis of the sensitivity to elevation of the gun and a manual Tc setting method for gunners.

- Ramjet burnout. This would ensure that Tc occurred at an "optimum" point almost exactly on the pseudo-vacuum trajectory but the location along it at Tc would be difficult to predict.

- At given pressure for altitude [Reference 5]. This would establish accurate baskets for given gun elevations assuming the altitude chosen was before ramjet burnout.

Several trajectories were simulated with a varying wind profile as a function of altitude in the Standard Atmosphere. These are shown at Figure 3-28 as compared to the pseudo-vacuum trajectory.

Velocities at time 101 seconds were measured and are shown at Figure 3-27. The total variation of extreme cases is from 2285 feet/sec to 2315 feet/sec, or only 30 feet/sec.

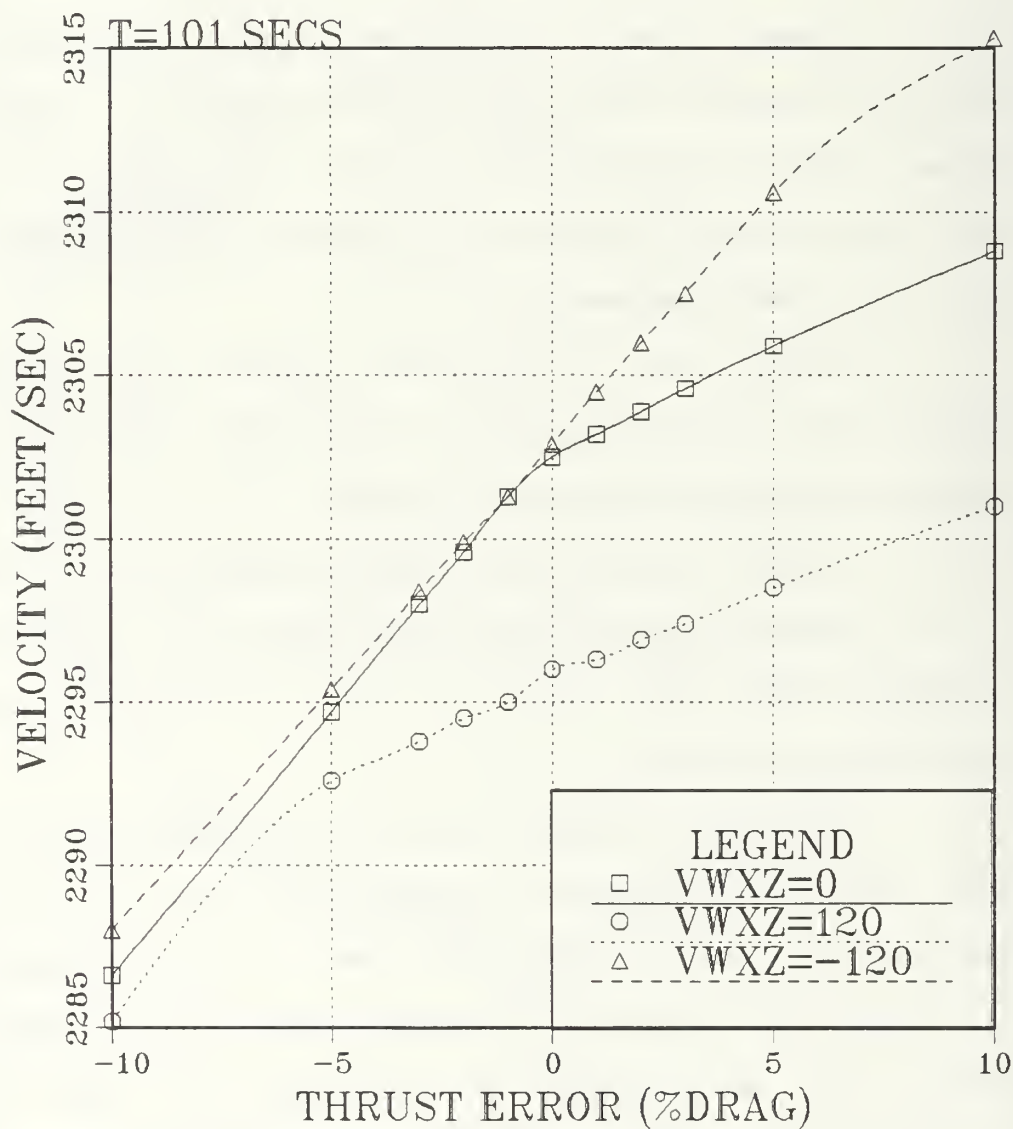


Figure 3-27 Velocity Sensitivity

Deviations from the ideal trajectory were correlated and tabulated in Table 3.5. Results were conservatively linearized and are presented in that manner. Wind errors are read in addition to the thrust errors at the left of the table. For example:

If thrust error=-5%
crosswind=120 ft/sec

predicted dispersion is X=-540 ft
Y=19 ft
Z=130 ft ;from ideal basket.

Table 3.5 Dispersion Analysis Results

Errors	Thrust Errors		Winds continuous 120 ft/sec			
	X	Z	Cross	Head		Tail
			Y	X	Z	X Z
0 %	0	0	.1	30	7	.1 .1
1 %	110	25	4	30	15	10 1
2 %	220	50	8	40	20	20 2
5 %	540	130	19	50	32	50 10
10 %	1100	345	38	90	50	100 30

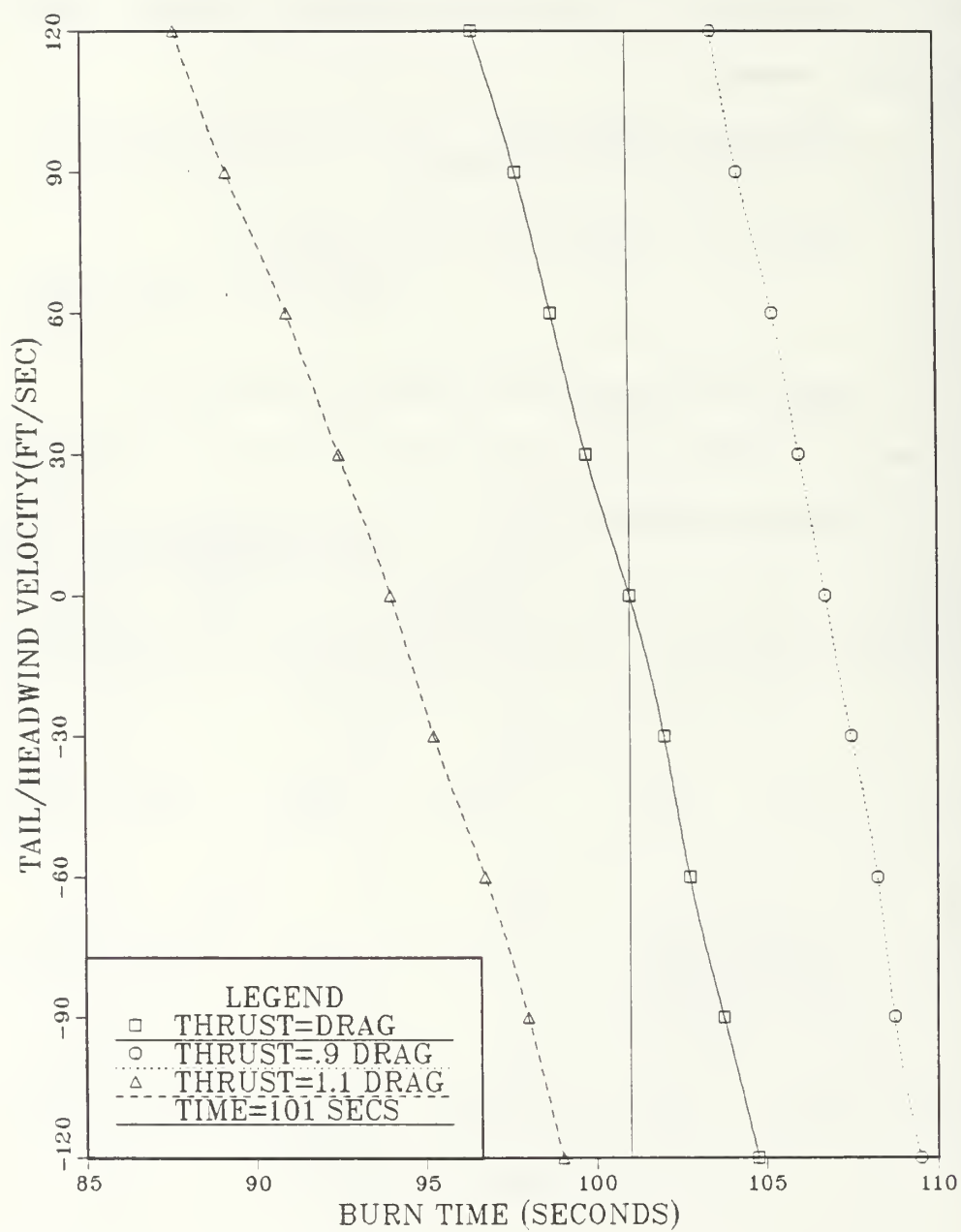


Figure 3-26 Tail/Headwind Effects (Burntime)

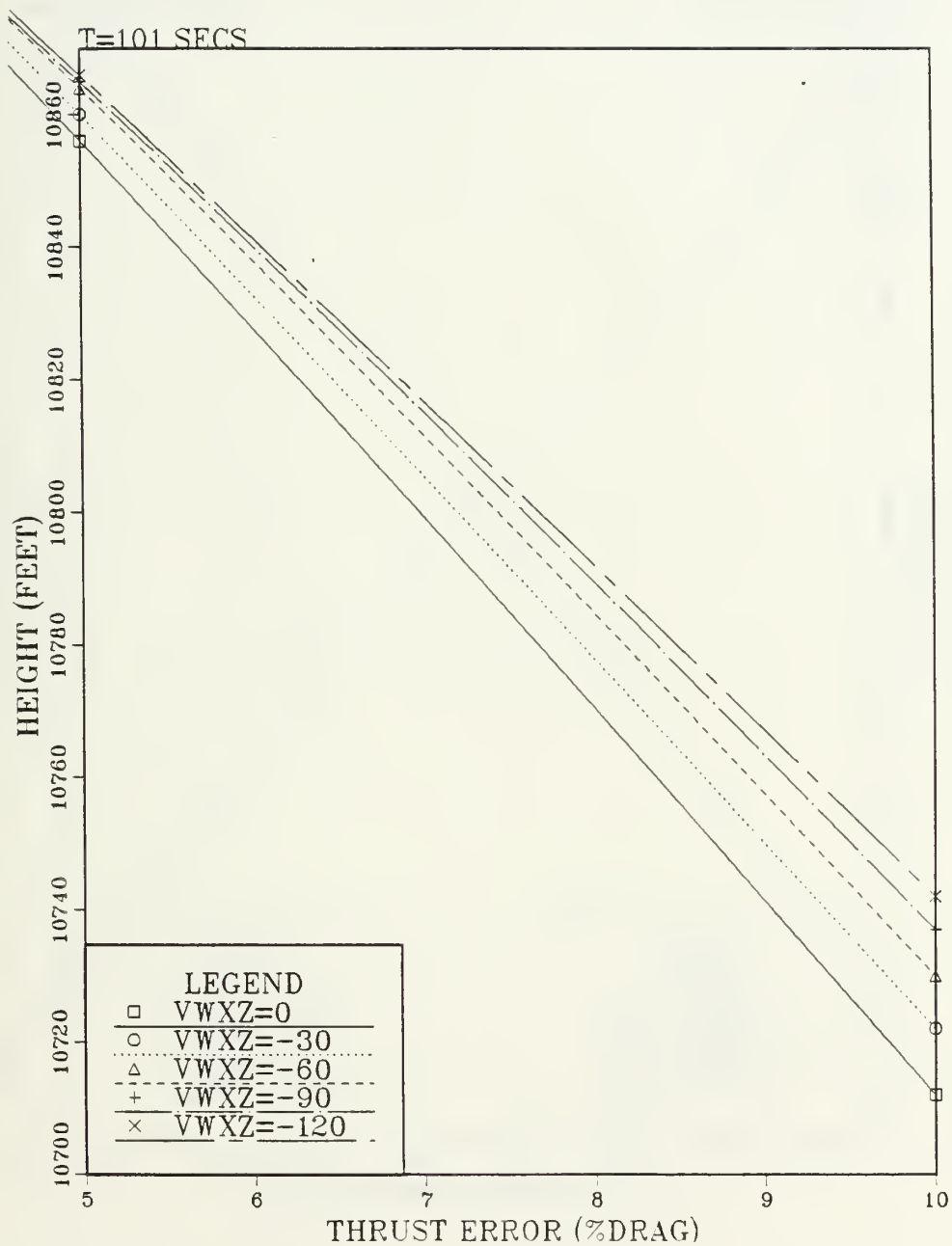


Figure 3-25C Tailwind Sensitivity (Height)

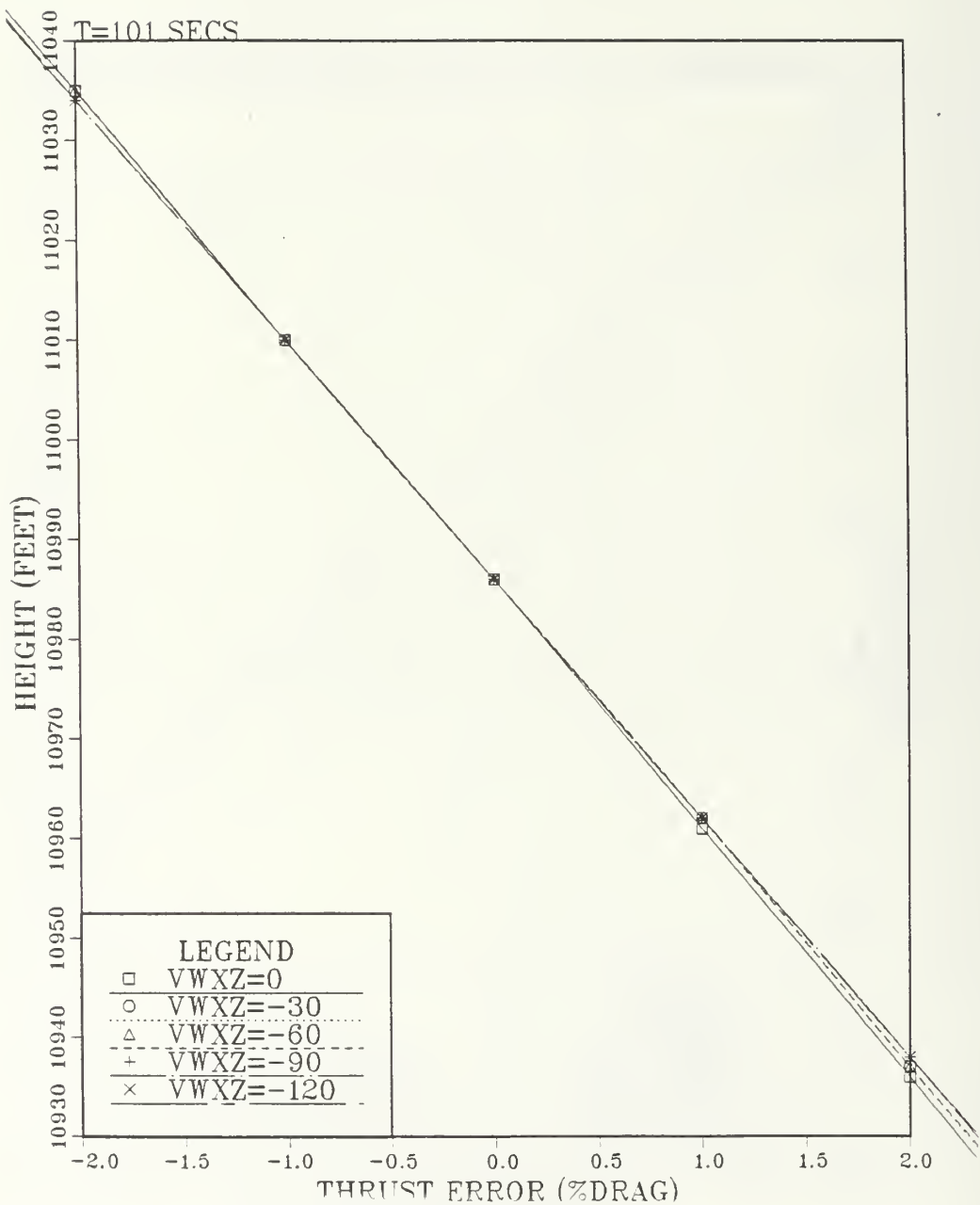


Figure 3-25B Tailwind Sensitivity (Height)

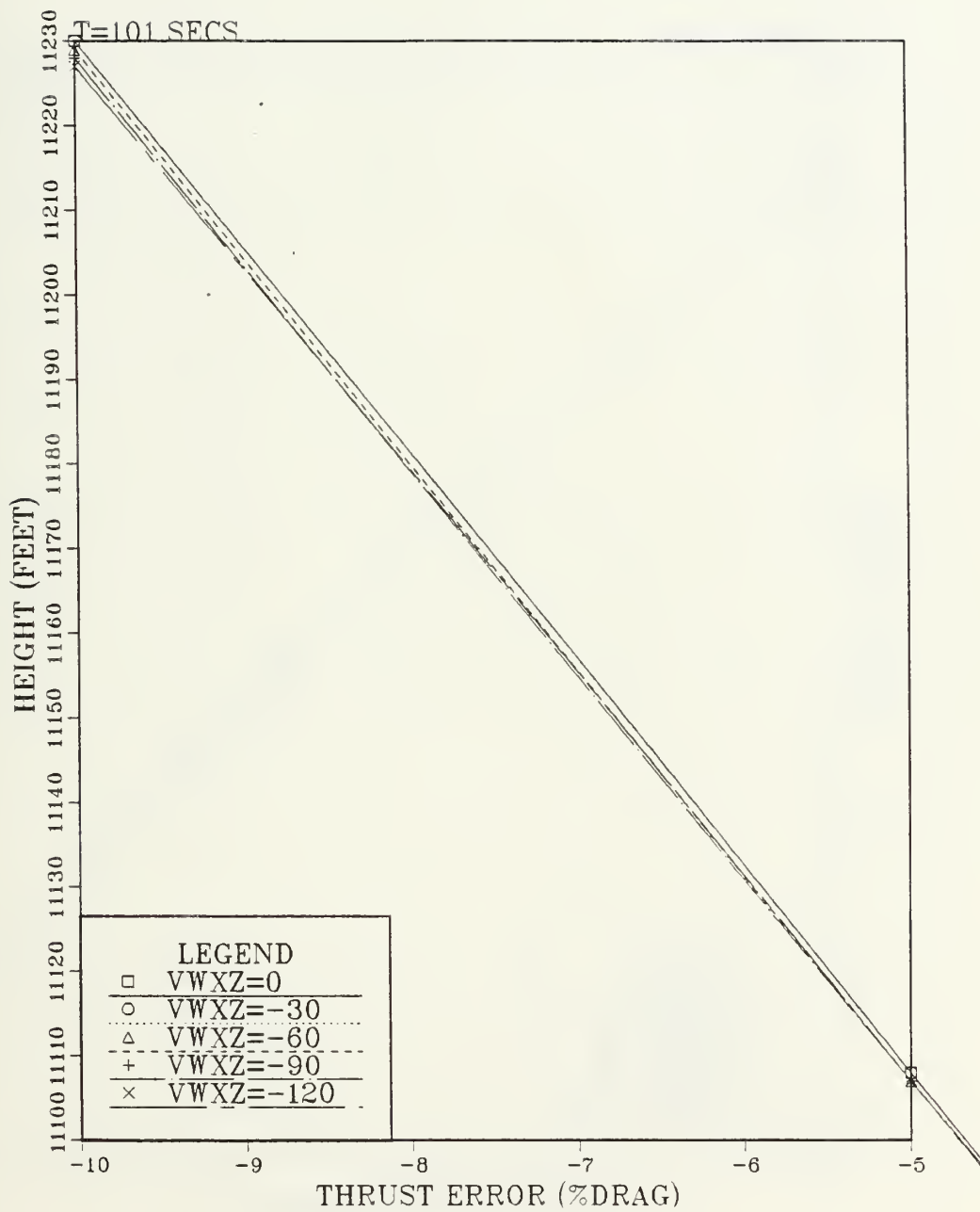


Figure 3-25A Tailwind Sensitivity (Height)

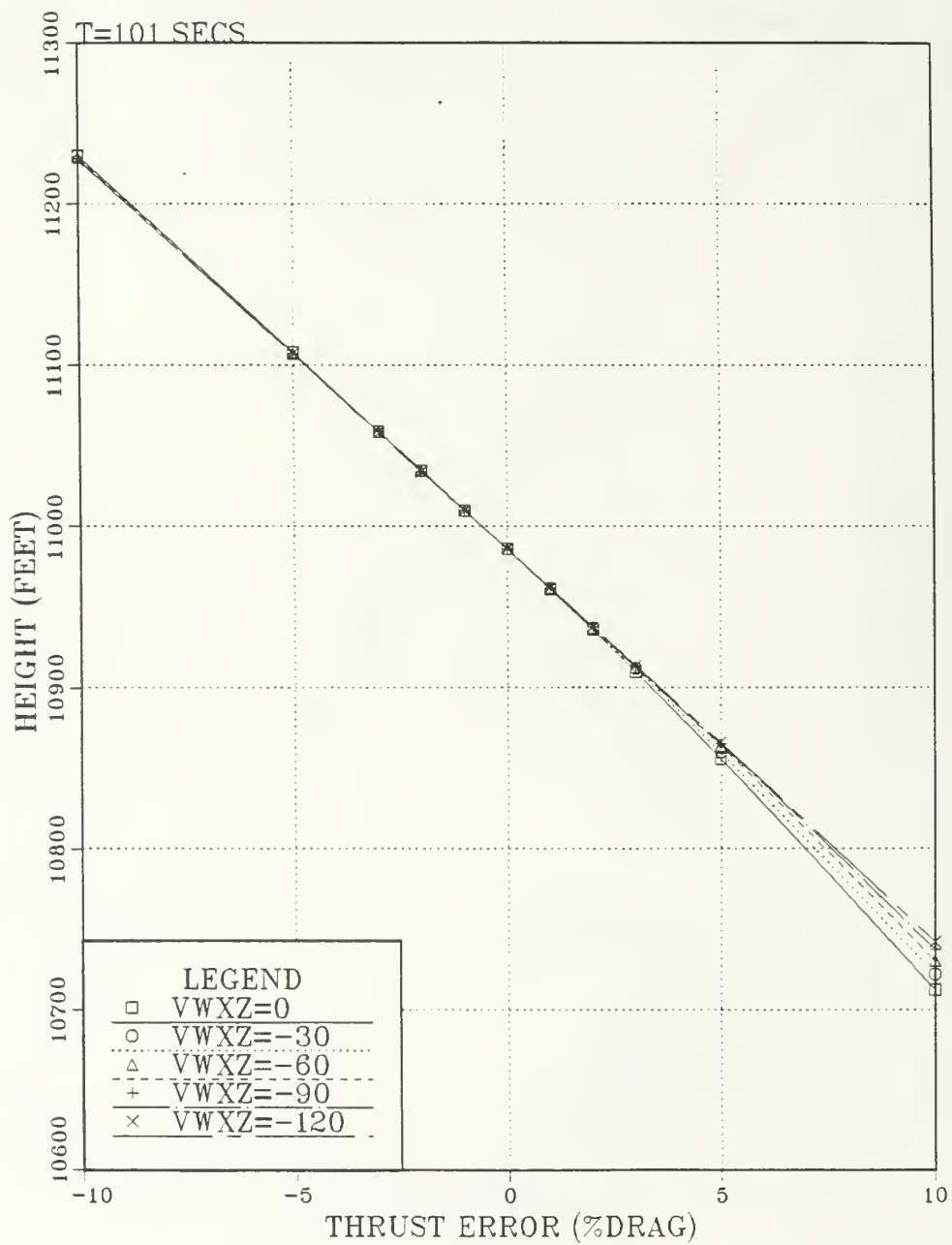


Figure 3-25 Tailwind Sensitivity (Height)

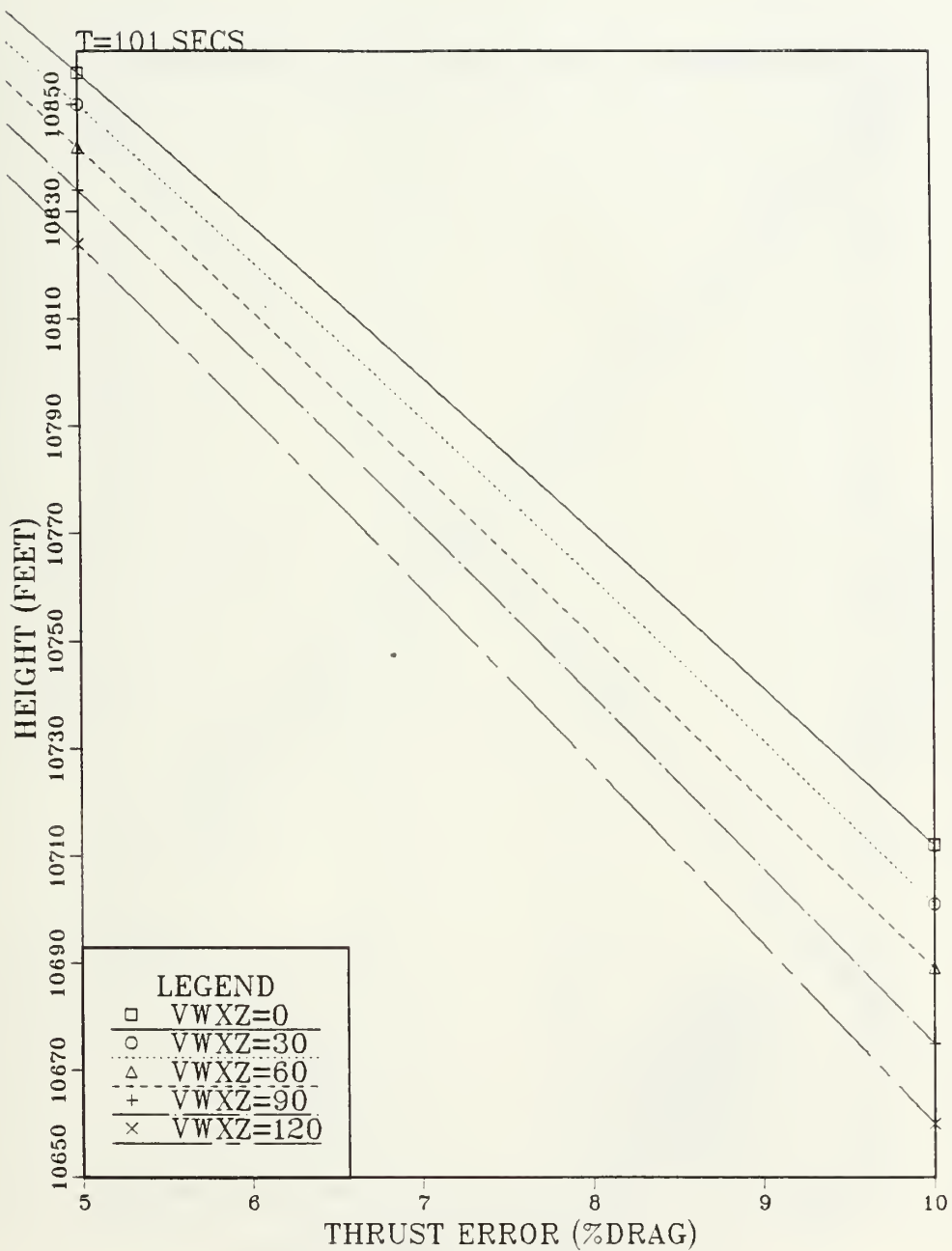


Figure 3-24C Headwind Sensitivity (Height)

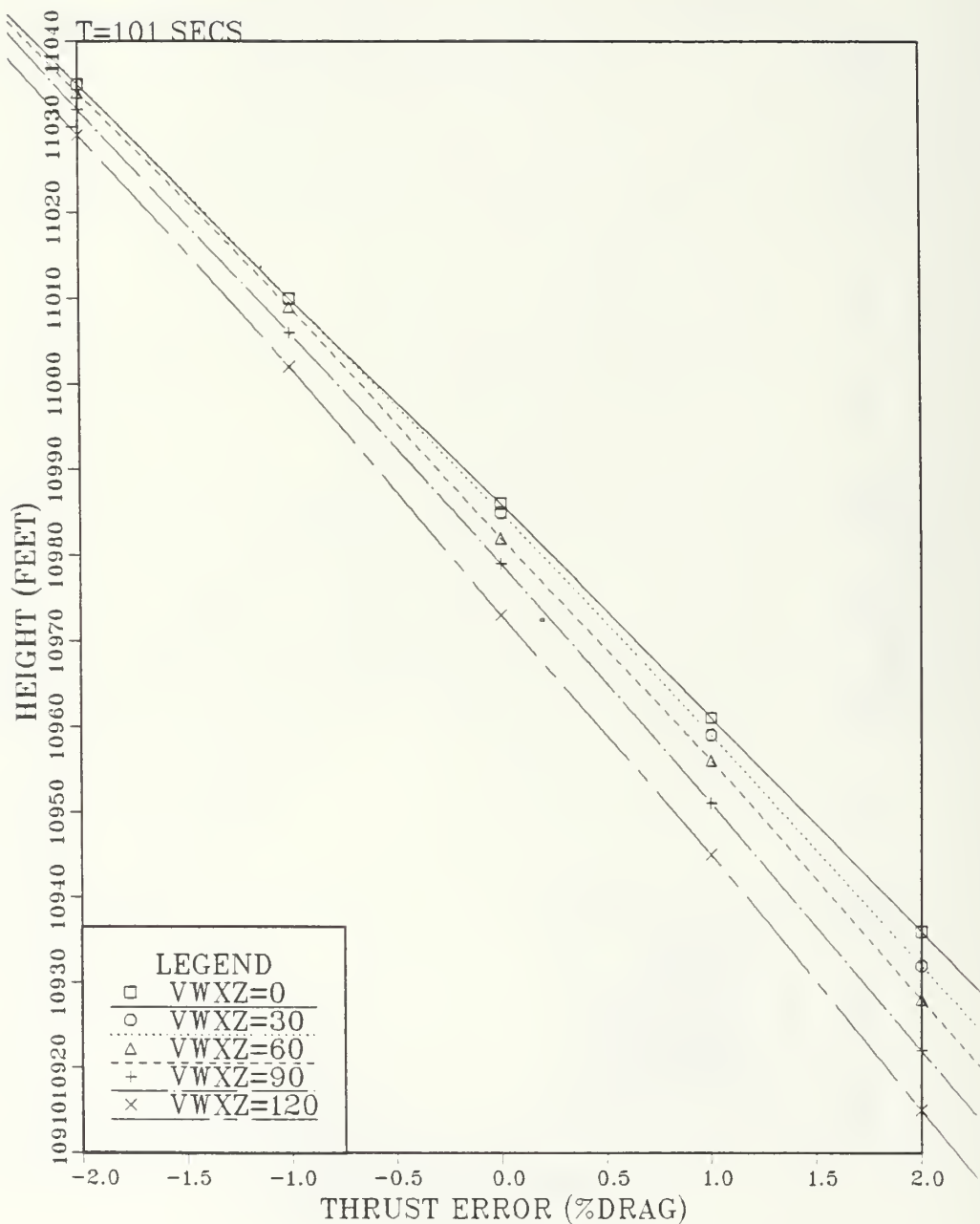


Figure 3-24B Headwind Sensitivity (Height)

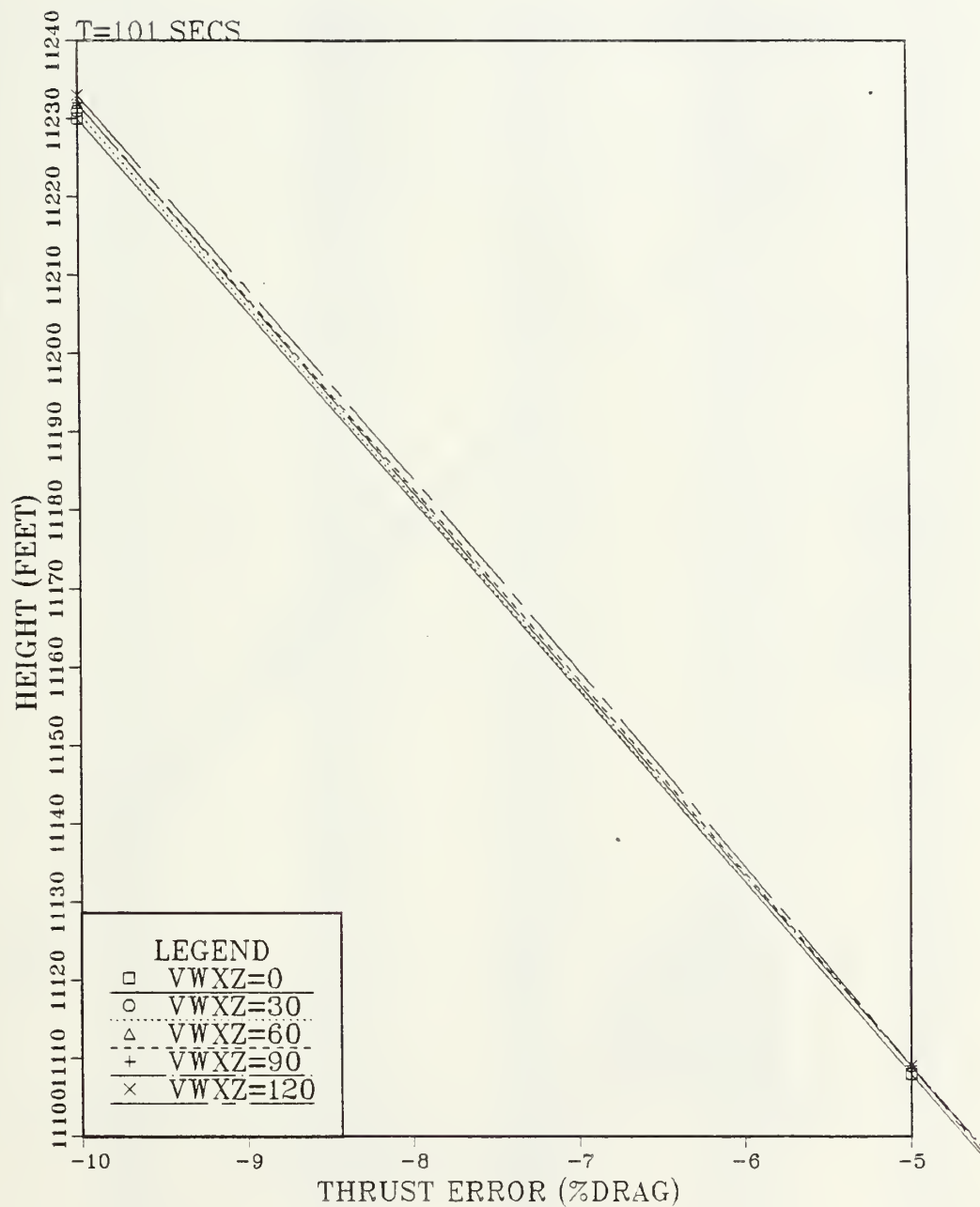


Figure 3-24A Headwind Sensitivity (Height)

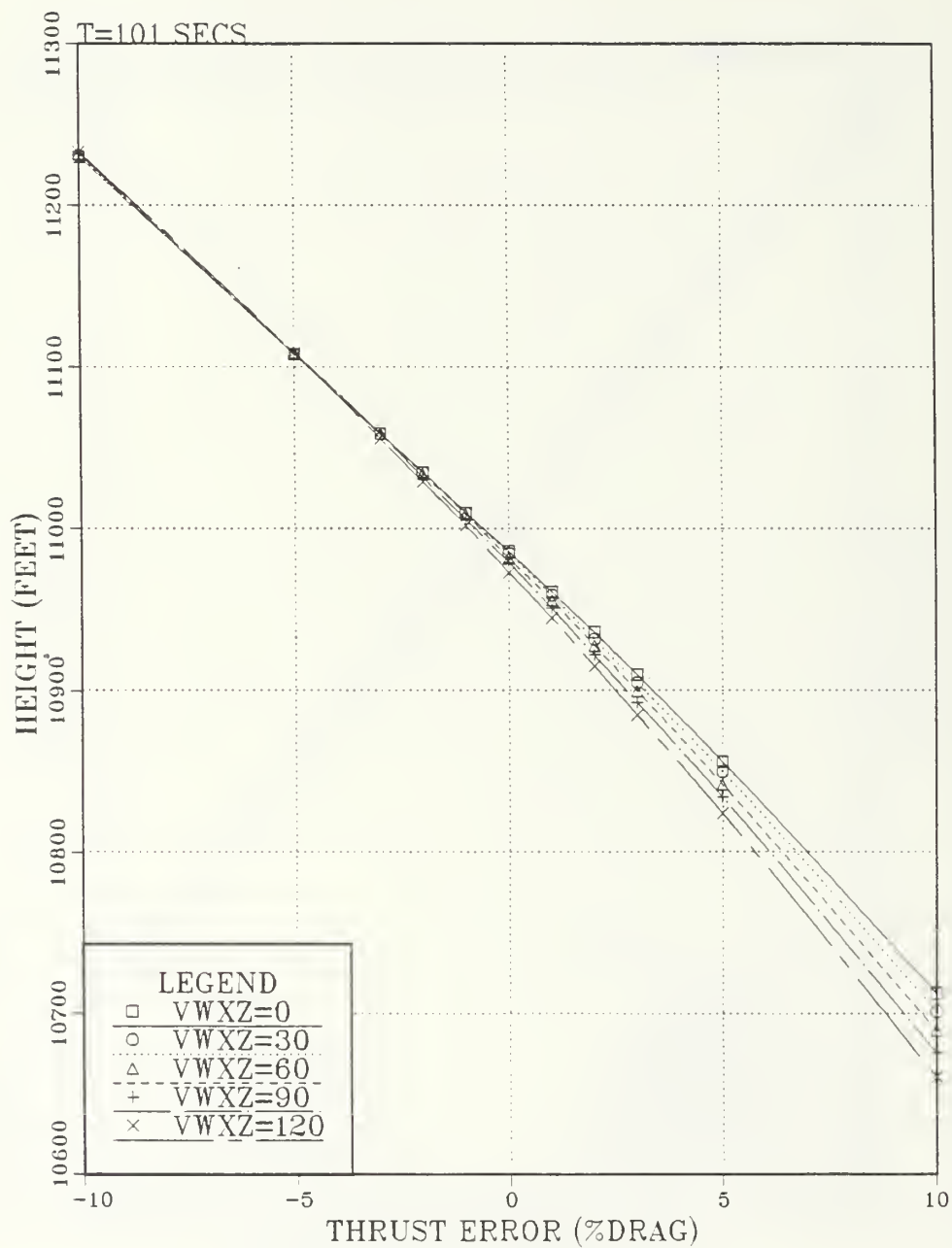


Figure 3-24 Headwind Sensitivity (Height)

TIME	X	Y	MASS	SPEED
0	0	0	225	2452
.5	866.913	862.891	225	2440.65
1	1733.83	1717.74	224.637	2429.36
1.5	2600.74	2564.54	224.286	2418.11
2	3467.65	3403.3	223.947	2406.93
2.5	4334.57	4234.02	223.618	2395.8
3	5201.48	5056.7	223.3	2384.73
3.5	6068.39	5871.32	222.993	2373.71
4	6935.3	6677.91	222.695	2362.75
4.5	7802.22	7476.46	222.407	2351.85
5	8669.13	8266.96	222.128	2341.01
5.5	9536.04	9049.41	221.858	2330.24
6	10403	9823.82	221.597	2319.52
6.5	11269.9	10590.2	221.344	2308.86
7	12136.8	11348.5	221.099	2298.27
7.5	13003.7	12098.8	220.861	2287.74
8	13870.6	12841	220.631	2277.28
8.5	14737.5	13575.2	220.409	2266.89
9	15604.4	14301.4	220.193	2256.55
9.5	16471.3	15019.5	219.983	2246.29
10	17338.3	15729.6	219.781	2236.1
10.5	18205.2	16431.6	219.584	2225.98
11	19072.1	17125.6	219.394	2215.92
11.5	19939	17811.5	219.209	2205.94
12	20805.9	18489.4	219.03	2196.03
12.5	21672.8	19159.2	218.856	2186.2
13	22539.7	19821	218.687	2176.43
13.5	23406.7	20474.8	218.523	2166.75
14	24273.6	21120.5	218.364	2157.14
14.5	25140.5	21758.2	218.21	2147.61
15	26007.4	22387.8	218.061	2138.15
15.5	26874.3	23009.4	217.915	2128.78
16	27741.2	23622.9	217.774	2119.49
16.5	28608.1	24228.4	217.637	2110.27
17	29475	24825.9	217.504	2101.14
17.5	30342	25415.3	217.374	2092.1
18	31208.9	25996.7	217.248	2083.14
18.5	32075.8	26570	217.126	2074.27
19	32942.7	27135.3	217.007	2065.48
19.5	33809.6	27692.5	216.891	2056.78
20	34676.5	28241.7	216.778	2048.17
20.5	35543.4	28782.9	216.669	2039.65
21	36410.3	29316	216.562	2031.23
21.5	37277.3	29841	216.458	2022.89
22	38144.2	30358.1	216.357	2014.65
22.5	39011.1	30867	216.258	2006.51
23	39878	31368	216.162	1998.46
23.5	40744.9	31860.9	216.068	1990.51
24	41611.8	32345.7	215.977	1982.66
24.5	42478.7	32822.5	215.888	1974.9
25	43345.7	33291.3	215.801	1967.25
25.5	44212.6	33752	215.717	1959.7
26	45079.5	34204.7	215.634	1952.26
26.5	45946.4	34649.3	215.553	1944.91
27	46813.3	35085.9	215.474	1937.68
27.5	47680.2	35514.4	215.397	1930.55
28	48547.1	35934.9	215.322	1923.53
28.5	49414	36347.4	215.249	1916.62
29	50281	36751.8	215.177	1909.82
29.5	51147.9	37148.2	215.048	1903.13

30	52014.8	37536.5	214.921	1896.55
30.5	52881.7	37916.8	214.794	1890.89
31	53748.6	38289	214.668	1883.74
31.5	54615.5	38653.2	214.542	1877.51
32	55482.4	39009.3	214.417	1871.4
32.5	56349.3	39357.4	214.292	1865.4
33	57216.3	39697.5	214.168	1859.53
33.5	58083.2	40029.5	214.045	1853.78
34	58950.1	40353.5	213.922	1848.14
34.5	59817	40669.5	213.799	1842.64
35	60683.9	40977.3	213.677	1837.25
35.5	61550.8	41277.2	213.556	1831.99
36	62417.7	41569	213.435	1826.86
36.5	63284.6	41852.7	213.314	1821.86
37	64151.6	42128.5	213.194	1816.98
37.5	65018.5	42396.1	213.075	1812.24
38	65885.4	42655.8	212.956	1807.62
38.5	66752.3	42907.3	212.837	1803.14
39	67619.2	43150.9	212.719	1798.79
39.5	68486.1	43386.4	212.601	1794.57
40	69353	43613.8	212.483	1790.49
40.5	70220	43833.3	212.366	1786.54
41	71086.9	44044.6	212.249	1782.73
41.5	71953.8	44247.9	212.133	1779.06
42	72820.7	44443.2	212.017	1775.52
42.5	73687.6	44630.5	211.901	1772.12
43	74554.5	44809.7	211.786	1768.87
43.5	75421.4	44980.8	211.671	1765.75
44	76288.3	45143.9	211.556	1762.78
44.5	77155.3	45299	211.441	1759.95
45	78022.2	45446	211.327	1757.26
45.5	78889.1	45585	211.213	1754.71
46	79756	45715.9	211.099	1752.31
46.5	80622.9	45838.8	210.986	1750.05
47	81489.8	45953.6	210.873	1747.94
47.5	82356.7	46060.4	210.76	1745.97
48	83223.7	46159.2	210.647	1744.15
48.5	84090.6	46249.9	210.534	1742.47
49	84957.5	46332.6	210.421	1740.95
49.5	85824.4	46407.2	210.309	1739.57
50	86691.3	46473.8	210.197	1738.34
50.5	87558.2	46532.3	210.085	1737.25
51	88425.1	46582.8	209.973	1736.32
51.5	89292	46625.3	209.861	1735.53
52	90158.9	46659.7	209.749	1734.89
52.5	91025.9	46686.1	209.637	1734.4
53	91892.8	46704.4	209.526	1734.06
53.5	92759.7	46714.7	209.414	1733.87
54	93626.6	46716.9	209.302	1733.83
54.5	94493.5	46711.1	209.191	1733.94
55	95360.4	46697.3	209.079	1734.19
55.5	96227.3	46675.3	208.967	1734.6
56	97094.3	46645.5	208.856	1735.16
56.5	97961.2	46607.4	208.744	1735.86
57	98828.1	46561.4	208.632	1736.71
57.5	99695	46507.4	208.521	1737.72
58	100562	46445.2	208.409	1738.86
58.5	101429	46375.1	208.297	1740.16
59	102296	46296.9	208.185	1741.61
59.5	103163	46210.6	208.073	1743.2
60	104030	46116.4	207.96	1744.94
60.5	104896	46014	207.848	1746.82
61	105763	45903.6	207.735	1748.86
61.5	106630	45785.2	207.623	1751.03
62	107497	45658.8	207.51	1753.36
62.5	108364	45524.2	207.396	1755.82

63	109231	45381.7	207.283	1758.43
63.5	110098	45231.1	207.169	1761.16
64	110965	45072.5	207.056	1764.08
64.5	111832	44905.8	206.942	1767.12
65	112699	44731.1	206.827	1770.3
65.5	113566	44548.4	206.713	1773.61
66	114433	44357.5	206.598	1777.07
66.5	115299	44158.7	206.482	1780.67
67	116166	43951.8	206.367	1784.4
67.5	117033	43736.9	206.251	1788.28
68	117900	43513.9	206.135	1792.28
68.5	118767	43282.9	206.018	1796.43
69	119634	43043.8	205.901	1800.7
69.5	120501	42796.6	205.784	1805.11
70	121368	42541.5	205.666	1809.65
70.5	122235	42278.4	205.548	1814.33
71	123102	42007.2	205.43	1819.13
71.5	123969	41727.8	205.311	1824.06
72	124835	41440.4	205.191	1829.13
72.5	125702	41145.1	205.072	1834.31
73	126569	40841.7	204.951	1839.63
73.5	127436	40530.2	204.831	1845.07
74	128303	40210.7	204.709	1850.63
74.5	129170	39883.1	204.588	1856.32
75	130037	39547.5	204.466	1862.12
75.5	130904	39204	204.343	1868.05
76	131771	38852.3	204.22	1874.1
76.5	132638	38492.6	204.096	1880.26
77	133505	38124.8	203.972	1886.55
77.5	134372	37749	203.847	1892.94
78	135238	37365.1	203.721	1899.46
78.5	136105	36973.2	203.595	1906.08
79	136972	36573.3	203.469	1912.82
79.5	137839	36165.2	203.342	1919.67
80	138706	35749.3	203.214	1926.63
80.5	139573	35325.3	203.086	1933.7
81	140440	34893.1	203.013	1940.88
81.5	141307	34453	202.939	1948.16
82	142174	34004.7	202.863	1955.55
82.5	143041	33548.5	202.785	1963.04
83	143908	33084.2	202.705	1970.63
83.5	144774	32611.9	202.624	1978.33
84	145641	32131.5	202.54	1986.13
84.5	146508	31643.2	202.454	1994.03
85	147375	31146.6	202.367	2002.02
85.5	148242	30642.1	202.277	2010.11
86	149109	30129.7	202.184	2018.3
86.5	149976	29608.9	202.09	2026.58
87	150843	29080.4	201.992	2034.96
87.5	151710	28543.7	201.893	2043.42
88	152577	27999	201.79	2051.98
88.5	153444	27446.2	201.685	2060.63
89	154311	26885.3	201.577	2069.37
89.5	155177	26316.6	201.466	2078.19
90	156044	25739.6	201.352	2087.11
90.5	156911	25154.7	201.235	2096.1
91	157778	24561.8	201.114	2105.19
91.5	158645	23960.8	200.99	2114.35
92	159512	23351.6	200.863	2123.6
92.5	160379	22734.5	200.732	2132.93
93	161246	22109.3	200.597	2142.34
93.5	162113	21476.1	200.458	2151.83
94	162980	20834.9	200.315	2161.39
94.5	163847	20185.7	200.168	2171.04
95	164713	19528.3	200.016	2180.76
95.5	165580	18862.2	199.86	2190.55

96	166447	18189.5	199.699	2200.42
96.5	167314	17508	199.533	2210.36
97	168181	16818.6	199.362	2220.38
97.5	169048	16121	199.186	2230.46
98	169915	15415.4	199.004	2240.62
98.5	170782	14701.8	198.817	2250.84
99	171649	13980	198.623	2261.13
99.5	172516	13250.3	198.424	2271.49
100	173383	12512.6	198.218	2281.92
100.5	174250	11766.9	198.006	2292.41

RAMJET BURNOUT BETWEEN T= 100.5 AND 101

APPENDIX E- THREE DEGREES OF FREEDOM RESULTS

VARIABLES & INITIAL CONDITIONS:

```

XDOT = 2188.670000
X = .0
YDOT = .0
Y = .0
THEDOT = .0
THETA = .0
M = 225.0000000
T = .0

CONSTANTS:
PHASE = .0
CMA = -2.308000000
A = .3491000000
DI = .6666670000
CMT = 190.0000000
CDO = .2760000000
PI = 3.141592654
ISP = .550000000
LAMBDA = 150000.0000
PI8 = .3926950817

SPECIAL FUNCTIONS:
ETA = ATAN(YICOT/XICOT)
VCG = (XDOT**2+YDOT**2)**.5
VW = 0
GAMMA = ATAN((YDOT+VW)/XDOT)
V = (XDOT**2+(YDOT+VW)**2)**.5
Q = .5*.00085068*V**2
K = C*DI*A
THEDBL = (CMA*K*(THETA-GAMMA)-((CMT*K*DI*THEDOT)/(V*2)))/I
ALPHA = GAMMA-THETA
CD = CDO+.5*CL*SIN(ALPHA)
CL = .091*ALPHA
L = CL*Q*A
D = C*CD*C*A
XDBL = (L*SIN(GAMMA)-D*CCS(GAMMA))/M
YDBL = (L*CCS(GAMMA)+D*SIN(GAMMA))/M
C = C
MDOT = (1-C)*(CDO+.5*CL*SIN(ALPHA))*C*A/(-ISP)
DELM = 225-M
I = (18.8-.0423*DELM)*32.2

DERIVATIVES:
D(XDOT/C(T)) = =

```

XDEL
 D(X /D(T)) = =
 XDCOT
 D(YDCOT /C(T)) = =
 YDBL
 D(Y /D(T)) = =
 YDCOT
 D(THEDCOT /C(T)) = =
 THEDEL
 D(THETA /D(T)) = =
 THEDCT
 D(M /D(T)) = =
 MDOOT

OUTPUTS:
 TITLE: THREE DEGREE CROSSWIND TRIAL
 TABULATE: T
 AT INTERVAL X
 .5000000000
 PLOT: X
 AGAINST: T
 PLCT: Y
 AGAINST: T
 PLCT: ALPHA
 AGAINST: T
 AT INTERVAL .25000000000
 VCG V MDOT

END CALCULATION WHEN M .LE. 198.000

THREE DEGREE CROSSWIND TRIAL

T	X	Y	VCG	V	MDOT
0	0	0	2188.7	2188.7	21637
1	1094.3	0	2188.7	2188.7	21637
2	3283.0	0	2188.7	2188.7	21637
3	4377.3	0	2188.7	2188.7	21637
4	5471.7	0	2188.7	2188.7	21637
5	6566.0	0	2188.7	2188.7	21637
6	7660.3	0	2188.7	2188.7	21637
7	8754.7	0	2188.7	2188.7	21637
8	9849.0	0	2188.7	2188.7	21637
9	10943.3	0	2188.7	2188.7	21637
10	12037.6	0	2188.7	2188.7	21637
11	13132.0	0	2188.7	2188.7	21637
12	14226.4	0	2188.7	2188.7	21637
13	15320.8	0	2188.7	2188.7	21637
14	16415.2	0	2188.7	2188.7	21637
15	17509.6	0	2188.7	2188.7	21637
16	18604.0	0	2188.7	2188.7	21637

33	000	72226.	0	2188.7	2188.7	2188.7	-0.21637
T	33	X	Y	VCG	V	MDGT	
33	000	73320.	00	2188.7	2188.7	21637	21637
33	000	74415.	00	2188.7	2188.7	21637	21637
33	000	75503.	00	2188.7	2188.7	21637	21637
33	000	76603.	00	2188.7	2188.7	21637	21637
33	000	77698.	00	2188.7	2188.7	21637	21637
33	000	78792.	00	2188.7	2188.7	21637	21637
33	000	79886.	00	2188.7	2188.7	21637	21637
33	000	80981.	00	2188.7	2188.7	21637	21637
33	000	82075.	00	2188.7	2188.7	21637	21637
33	000	83169.	00	2188.7	2188.7	21637	21637
33	000	84264.	00	2188.7	2188.7	21637	21637
33	000	85358.	00	2188.7	2188.7	21637	21637
33	000	86452.	00	2188.7	2188.7	21637	21637
33	000	87547.	00	2188.7	2188.7	21637	21637
33	000	88641.	00	2188.7	2188.7	21637	21637
33	000	89735.	00	2188.7	2188.7	21637	21637
33	000	90830.	00	2188.7	2188.7	21637	21637
33	000	91924.	00	2188.7	2188.7	21637	21637
33	000	93018.	00	2188.7	2188.7	21637	21637
33	000	94113.	00	2188.7	2188.7	21637	21637
33	000	95207.	00	2188.7	2188.7	21637	21637
33	000	96301.	00	2188.7	2188.7	21637	21637
33	000	97396.	00	2188.7	2188.7	21637	21637
33	000	98490.	00	2188.7	2188.7	21637	21637
33	000	99584.	00	2188.7	2188.7	21637	21637
33	000	100680.	00	2188.7	2188.7	21637	21637
33	000	101770.	00	2188.7	2188.7	21637	21637
33	000	102870.	00	2188.7	2188.7	21637	21637
33	000	103960.	00	2188.7	2188.7	21637	21637
33	000	105060.	00	2188.7	2188.7	21637	21637
33	000	106150.	00	2188.7	2188.7	21637	21637
33	000	107240.	00	2188.7	2188.7	21637	21637
33	000	108340.	00	2188.7	2188.7	21637	21637
33	000	109430.	00	2188.7	2188.7	21637	21637
33	000	110530.	00	2188.7	2188.7	21637	21637
33	000	111620.	00	2188.7	2188.7	21637	21637
33	000	112720.	00	2188.7	2188.7	21637	21637
33	000	113810.	00	2188.7	2188.7	21637	21637
33	000	114900.	00	2188.7	2188.7	21637	21637
33	000	116000.	00	2188.7	2188.7	21637	21637
33	000	117090.	00	2188.7	2188.7	21637	21637
33	000	118190.	00	2188.7	2188.7	21637	21637
33	000	119280.	00	2188.7	2188.7	21637	21637
33	000	120380.	00	2188.7	2188.7	21637	21637
33	000	121470.	00	2188.7	2188.7	21637	21637


```

END CF RUN
VARIABLES & INITIAL CONDITIONS:
XDOT = 218.470000
X = .0
YDOT = .0
Y = .0
THEDCT = .0
THETA = .0
M = 225.0000000
T = .0

CONSTANTS:
PHASE = .0
CMA = -2.308000000
A = .3491000000
DI = .6666670000
CMT = .1900000000
CDO = .2760000000
PI = 3.141592654
ISP = 950.0000000
LAMBDA = 15000.00000
PI8 = .3526595817

SPECIAL FUNCTIONS:
ETA = ATAN(YDOT/XDOT)
VCG = (XCCT**2+YCCT**2)**.5
VM = 60
GAMMA = ATAN((YCCT+VM)/XCCT)
V = (XCCT**2+(YCCT+VM)**2)**.5
Q = .5*.00085068**2
K = C#DI*A
THEDBL = (CMA*K*(THETA-GAMMA)-((CMT*K*DI*THEDCT)/(V*2)))/I
ALPHA = GAMMA-THETA
CD = CDO+.5*CL*SIN(ALPHA)
CL = .091*ALPHA
L = CL*Q*A
D = C*CD*C*A
XDBL = (L*SIN(GAMMA)-D*CCS(GAMMA))/M
YDBL = (L*CCS(GAMMA)+D*SIN(GAMMA))/M
C = C
MDOT = (1-C)*(CDO+.5*CL*SIN(ALPHA))*Q*A/(-ISP)
DELM = 225-M
I = (18.8-.0423*DELM)*32.2

DERIVATIVES:
D(XDOT/C(T)) = =
D(X/YD(T)) = =

```

XDOT
 D(YDCT / C(T)) = =
 YDBL
 D(Y / D(T)) = =
 YDOT
 D(THEDCT / D(T)) = =
 THEDBL
 D(THETA / C(T)) = =
 THEDCT
 D(M / D(T)) = =
 MDCT

OUTPUTS:

TITLE: THREE DEGREE CRCSSWIND TRIAL
 TABULATE: T
 AT INTERVAL X Y VCG V MDOT
 PLCT: X .50000000000
 AGAINST: T
 PLCT: Y
 AGAINST: T
 PLOT: ALPHA
 AGAINST: T AT INTERVAL .250C000C00

END CALCULATION WHEN M .LE. 198.000

THREE DEGREE CRCSSWIND TRIAL

T	C	X	Y	VCG	V	MDOT
.50000	0	1094.3	0	2188.7	2189.5	-.21655
1.0000	1	188.7	.352100	2188.7	2189.5	-.21654
1.5000	2	83.0	.644660	2188.7	2189.5	-.21653
2.0000	3	37.3	.846280	2188.7	2189.5	-.21653
2.5000	4	17.7	.868930	2188.7	2189.5	-.21653
3.0000	5	6.6	.706620	2188.7	2189.5	-.21654
3.5000	6	60.3	.437260	2188.7	2189.5	-.21653
4.0000	7	154.7	.186440	2188.7	2189.5	-.21654
4.5000	8	49.0	.699920	2188.7	2189.5	-.21655
5.0000	9	4.3	.141540	2188.7	2189.5	-.21654
5.5000	0	33.8	.368850	2188.7	2189.5	-.21653
6.0000	1	22.6	.649350	2188.7	2189.5	-.21655
6.5000	2	22.6	.857440	2188.7	2189.5	-.21655
7.0000	3	32.1	.901760	2188.7	2189.5	-.21655
7.5000	4	15.	.766300	2188.7	2189.5	-.21654
8.0000	5	50.	.516890	2188.7	2189.5	-.21654
8.5000	6	04.	.270390	2188.7	2189.5	-.21654
9.0000	7	98.	.141090	2188.7	2189.5	-.21654
9.5000	8	792.	.188760	2188.7	2189.5	-.21654

[illegible]

T	X	Y	CG	V	MDG T
33	73320.	970130-02	21888.77	2189.	21653
34	74415.	103780-01	21888.77	2189.	21654
35	75503.	888660-02	21888.77	2189.	21653
36	76608.	696270-02	21888.77	2189.	21653
37	77698.	551950-02	21888.77	2189.	21654
38	78792.	523930-02	21888.77	2189.	21653
39	79886.	626130-02	21888.77	2189.	21653
40	80981.	812370-02	21888.77	2189.	21653
41	82075.	998240-02	21888.77	2189.	21654
42	83169.	110050-01	21888.77	2189.	21653
43	84264.	107520-01	21888.77	2189.	21654
44	85358.	937820-02	21888.77	2189.	21653
45	86452.	755330-02	21888.77	2189.	21653
46	87547.	614710-02	21888.77	2189.	21654
47	88641.	582690-02	21888.77	2189.	21653
48	89735.	675160-02	21888.77	2189.	21653
49	90830.	850390-02	21888.77	2189.	21653
50	91924.	102890-01	21888.77	2189.	21654
51	93018.	113060-01	21888.77	2189.	21653
52	94113.	111160-01	21888.77	2189.	21654
53	95207.	984560-02	21888.77	2189.	21653
54	96301.	811630-02	21888.77	2189.	21653
55	97396.	675610-02	21888.77	2189.	21654
56	98490.	641310-02	21888.77	2189.	21653
57	99584.	725800-02	21888.77	2189.	21653
58	100680+06	890990-02	21888.77	2189.	21653
59	101770+06	106190-01	21888.77	2189.	21654
60	102870+06	116180-01	21888.77	2189.	21653
61	103960+06	114740-01	21888.77	2189.	21653
62	105060+06	102930-02	21888.77	2189.	21653
63	106150+06	865440-02	21888.77	2189.	21653
64	107240+06	734720-02	21888.77	2189.	21653
65	108340+06	695630-02	21888.77	2189.	21654
66	109430+06	777770-02	21888.77	2189.	21653
67	110530+06	933830-02	21888.77	2189.	21653
68	111620+06	109710-01	21888.77	2189.	21653
69	112720+06	119410-01	21888.77	2189.	21654
70	113810+06	118280-01	21888.77	2189.	21653
71	114910+06	107220-01	21888.77	2189.	21653
72	116000+06	917050-02	21888.77	2189.	21653
73	117090+06	792150-02	21888.77	2189.	21653
74	118190+06	757550-02	21888.77	2189.	21653
75	119280+06	830640-02	21888.77	2189.	21653
76	120380+06	978610-02	21888.77	2189.	21653
77	121470+06	1134420-01	21888.77	2189.	21653
78	122570+06	1227420-01	21888.77	2189.	21653
79	123660+06		21888.77	2189.	21653

57.000	124750+06	21800-01	788.77	89.55	21653
57.500	125850+06	111380-01	2183.77	189.22	21653
58.000	126940+06	966710-02	2183.77	189.22	21653
58.500	128040+06	848040-02	2183.77	189.22	21653
59.000	129130+06	815010-02	2183.77	189.22	21653
59.500	130230+06	884380-02	2183.77	189.22	21653
60.000	131320+06	102510-01	2183.77	189.22	21653
60.500	132410+06	117310-01	2183.77	189.22	21653
61.000	133510+06	126180-01	2183.77	189.22	21653
61.500	134600+06	125300-01	2183.77	189.22	21653
62.000	135700+06	115410-01	2183.77	189.22	21653
62.500	136790+06	101470-01	2183.77	189.22	21653
63.000	137890+06	902550-02	2183.77	189.22	21653
63.500	138980+06	872020-02	2183.77	189.22	21653
64.000	140070+06	938780-02	2183.77	189.22	21653
64.500	141170+06	107290-01	2183.77	189.22	21653
65.000	142260+06	121350-01	2183.77	189.22	21653
65.500	143360+06	129720-01	2183.77	189.22	21653
66.000	144450+06	128790-01	2183.77	189.22	21653
66.500	145550+06	119340-01	2183.77	189.22	21653
67.000	146640+06	106120-01	2183.77	189.22	21653
67.500	147740+06	955840-02	2183.77	189.22	21653
68.000	148830+06	928610-02	2183.77	189.22	21653

75.000	149920+06	Y993710-02	UC8.77	89.55	MD013
75.500	151020+06	112200-01	2183.77	189.22	21653
76.000	152110+06	112520-01	2183.77	189.22	21653
76.500	153210+06	113330-01	2183.77	189.22	21653
77.000	154300+06	132270-01	2183.77	189.22	21653
77.500	155400+06	123180-01	2183.77	189.22	21653
78.000	156490+06	110650-01	2183.77	189.22	21653
78.500	157580+06	100810-01	2183.77	189.22	21653
79.000	158680+06	984810-02	2183.77	189.22	21653
79.500	159770+06	104910-01	2183.77	189.22	21653
80.000	160870+06	117210-01	2183.77	189.22	21653
80.500	161960+06	112980-01	2183.77	189.22	21653
81.000	163060+06	137010-01	2183.77	189.22	21653
81.500	164150+06	135750-01	2183.77	189.22	21653
82.000	165240+06	112690-01	2183.77	189.22	21653
82.500	166330+06	115070-01	2183.77	189.22	21653
83.000	167430+06	115950-01	2183.77	189.22	21653
83.500	168530+06	104070-01	2183.77	189.22	21653
84.000	169620+06	110480-01	2183.77	189.22	21653
84.500	170720+06	122310-01	2183.77	189.22	21653
85.000	171810+06	110180-01	2183.77	189.22	21653
85.500	172900+06	1340750-01	2183.77	189.22	21653
86.000	174000+06	139230-01	2183.77	189.22	21653

[illegible]

[illegible]

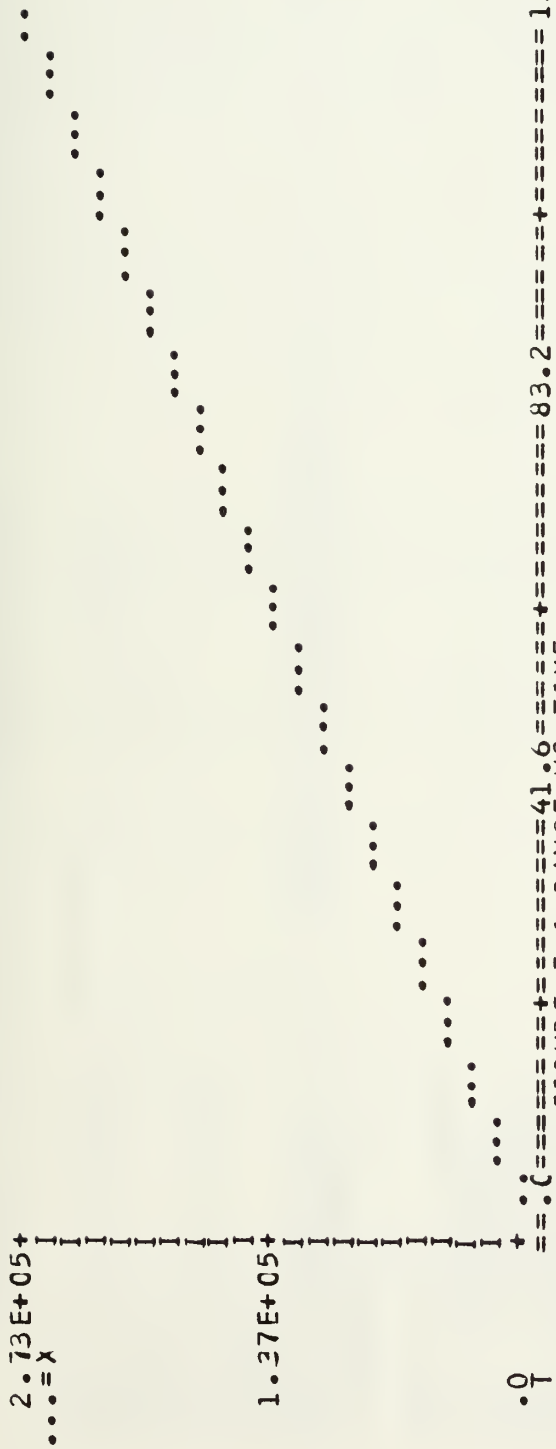


FIGURE E-1 RANGE VS TIME

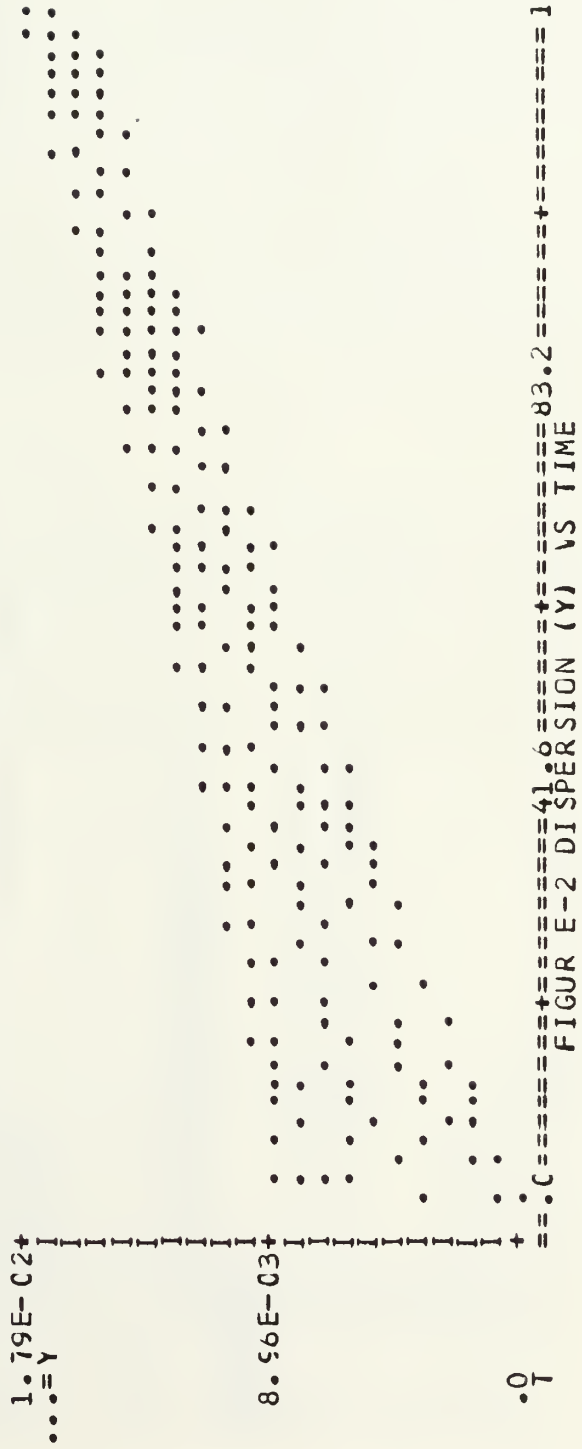
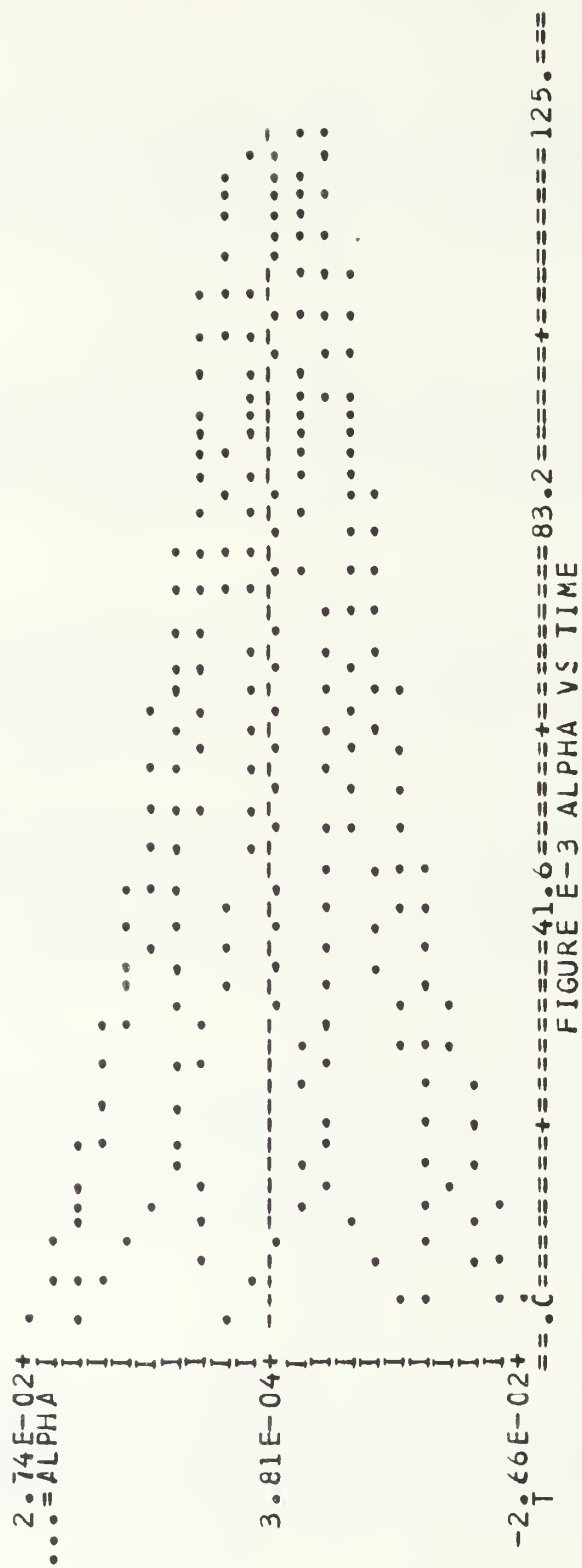


FIGURE E-2 DISPERSION (Y) VS TIME



APPENDIX F-FIVE DEGREES OF FREEDOM RESULTS

VARIABLES & INITIAL CONDITIONS:

XDOT = 1733.564000

X = .0

YDOT = .0

Y = .0

ZDOT = 1733.564000

Z = .0

THEDCT = .0

TH = .0

DELDCT = .0

DE = .7853980000

M = 225.0000000

T = .0

CONSTANTS:

CMA = -2.308000000

A = .3491000000

DI = .6666670000

ADI = .2327300000

DI2 = .4444440000

CMT = 190.0000000

ISP = 950.0000000

G = 32.17400000

CDO = 2760000000

K = 1.000000000

R = .0

SPECIAL FUNCTIONS:

ROUT = (2116.22*(1-(.0035662*Z/518.688))**.5*256)/

(1716.5*(518.688-(.0035662*Z)))

RO = CDEIF(Z,.6085,ROT,.001271)

VWXY = 0

VWXZ = 0

GA = ATAN((YDOT+VWXY)/(XCCT+VWXZ))

O = ATAN(ZDOT/(XCOT+VWXZ))

VCG = (XCCT**2+YDOT**2+ZCCT**2)**.5

V = ((XCCT+VWXZ)**2+(YDOT+VWXY)**2+ZDCT**2)**.5

AL = C-DE

BE = GA-TH

Q = (RO*V**2)/Z

LY = .091*BE*CA

L = .091*AL*CA

DY = D*CCS(O)/COS(GA)

D = ((-1025*V/(2402.88*(518.688-(.0035662*Z))**.5+.5015)

+ .5*(.091*AL)*SIN(AL))*CA

```

DRAG = D/COS(GA)
C = CDEF(M,158,1,R)
DELM = 225-M
I = (18.8-.0423*DELM)*32.2
MDOT = (1-C)*LAG/(-ISP)

DERIVATIVES:
D(XDCT/D(T)) = =
(L*CSIN(O)-C*C*CS(O)+LY*SIN(GA)-C*DY*CS(GA))/M
D(X/D(T)) = =
XDCT
D(YDCT/D(T)) = =
(LY*CS(GA)+C*DY*SIN(GA))/M
D(Y/D(T)) = =
YDCT
D(ZDCT/D(T)) = =
(L*CS(O)+C*D*SIN(O)-M*G)/M
D(Z/D(T)) = =
ZDOT
D(THEDCT/D(T)) = =
(CMA*C*ACI*(TF-GA)-((CMT*Q*ADI*DI*THEDCT)/(V*2)))/I
D(TH/D(T)) = =
THEDCT
D(DELDCT/D(T)) = =
(CMA*G*ACI*(DE-O)-((CMT*Q*ADI*DI*DELDCT)/(V*2)))/I
D(DE/D(T)) = =
CELDOT
D(M/D(T)) = =
MDCT

```

```

OUTPUTS:
TITLE: FIVE DEGREE
TABULATE: T X Y Z MDOT VCG M
AT INTERVAL -5000000000
PLCT: X Z
AGAINST: T
PLOT: AL EE
AGAINST: T
PLCT: Y
AGAINST: T AT INTERVAL .2500000000
END CALCULATION WHEN MDOT .GE. .0

```

FIVE DEGREE

T	X	Y	Z	MDUT	VCG
0	866	00	0	72555	24440
1	1733	00	17	70183	24449
2	2600	00	17	67789	24417
3	3467	00	17	65666	24066
4	4333	00	25	63355	23954
5	5200	00	35	61501	23873
6	6067	00	50	59519	23732
7	6934	00	70	57607	23651
8	7801	00	76	55763	23545
9	8667	00	93	53984	23451
0	9534	00	95	52267	23409
1	10401	00	02	50612	23315
2	11268	00	22	49015	23198
3	12135	00	38	47474	23087
4	13002	00	57	45988	22974
5	13869	00	77	44555	22876
6	14735	00	99	43177	22766
7	15602	00	29	41833	22656
8	16469	00	59	40551	22545
9	17336	00	77	39311	22435
0	18202	00	99	38113	22325
1	19069	00	29	36957	22215
2	19936	00	49	35843	22105
3	20803	00	68	34762	21995
4	21670	00	86	33732	21885
5	22536	00	11	32737	21776
6	23403	00	18	31767	21666
7	24270	00	41	30833	21556
8	25137	00	74	29938	21447
9	26003	00	94	29072	21338
0	26870	00	15	28231	21228
1	27737	00	39	27433	21119
2	28604	00	64	26653	21010
3	29471	00	89	25903	20901
4	30337	00	11	25188	20792
5	31204	00	32	24480	20683
6	32071	00	55	23809	20575
7	32938	00	79	23153	20467
8	33804	00	10	22533	20359
9	34671	00	36	21928	20251
0	35538	00	67	21345	20144
1	36405	00	97	20783	20036
2	37272	00	28	20240	19929
3	38139	00	52	19717	19821
4	39006	00	78	19213	19714

2006	1	1872	30861	0	39005
1998	1	18256	31362	0	35872
1990	1	17803	31855	0	40739
1982	5	17367	32539	0	41605
1974	5	16946	32816	0	42472
1966	5	16535	33285	0	43339
1959	3	16148	33745	0	44206
1951	9	15770	34158	0	45073
1944	6	15406	34642	0	45939
1937	3	15055	35079	0	46806
1930	2	14717	35507	0	47673
1923	3	14391	35928	0	48540
1919	5	13584	36340	0	49407
1902	8	12543	36744	0	50273
1899	5	12285	37140	0	51140
1896	2	12139	37529	0	52007
1889	7	12499	37909	0	52874
1883	4	12855	38281	0	53740
1877	2	12471	38645	0	54607
1871	1	12458	39001	0	55474
1865	2	12445	39349	0	56341
1859	3	12432	39689	0	57208

VC	4	MDOT	Z	Y	X
1853	4	24197	40221	0	58074
1847	8	24074	40345	0	58941
1842	3	23954	40660	0	59808
1836	5	23837	40968	0	60675
1831	7	23723	41268	0	61541
1826	5	23612	41559	0	62408
1821	5	23509	41843	0	63275
1816	6	23397	42119	0	64142
1811	9	23297	42386	0	65009
1807	3	23198	42646	0	65875
1802	8	23102	42857	0	66742
1798	5	23009	43141	0	67609
1794	2	22919	43376	0	68476
1790	2	22832	43603	0	69342
1786	2	22748	43823	0	70209
1782	4	22667	44034	0	71076
1778	7	22589	44232	0	71943
1775	2	22514	44419	0	72810
1771	8	22442	44679	0	73676
1768	6	22373	44969	0	74543
1765	4	22308	45132	0	75410
1759	5	22245	45287	0	76277
1757	0	22189	45434	0	77143
1751	0	22129		0	78010

T
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10228D+06
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10401D+06
10488D+06
10575D+06
10661D+06
10748D+06
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10922D+06
11008D+06
11095D+06
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11268D+06
11355D+06
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11788D+06

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43496.

MDUT
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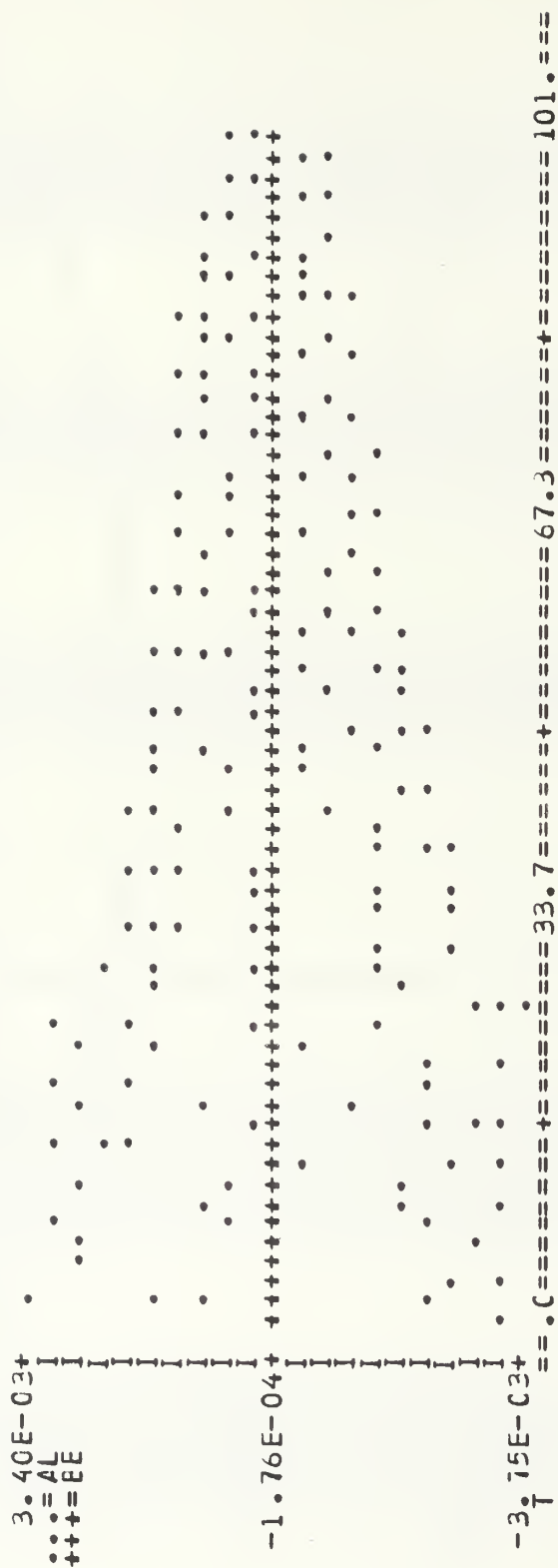
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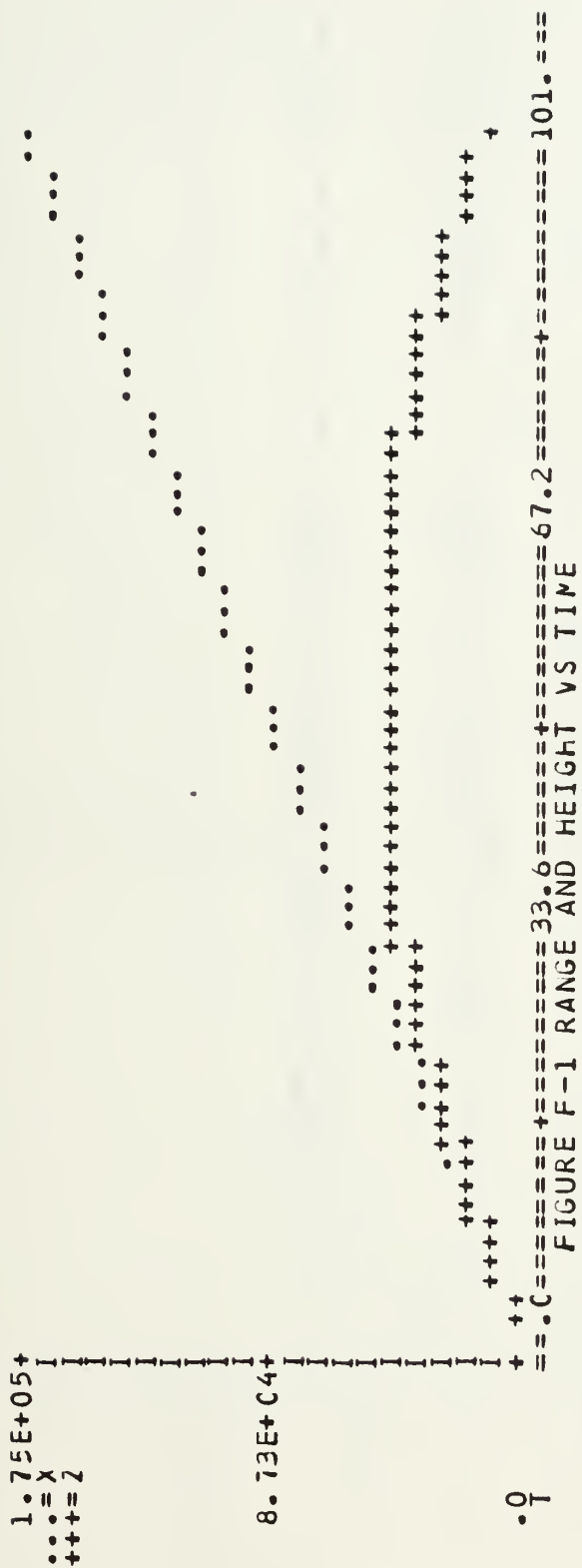
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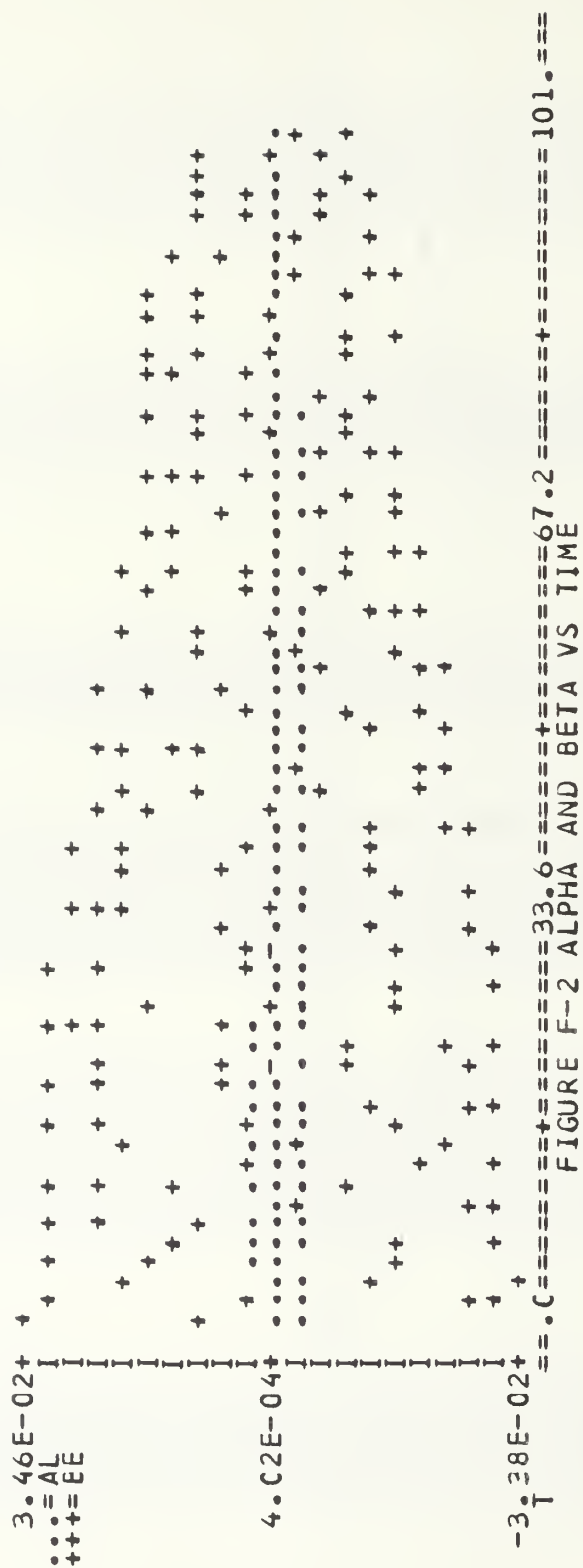
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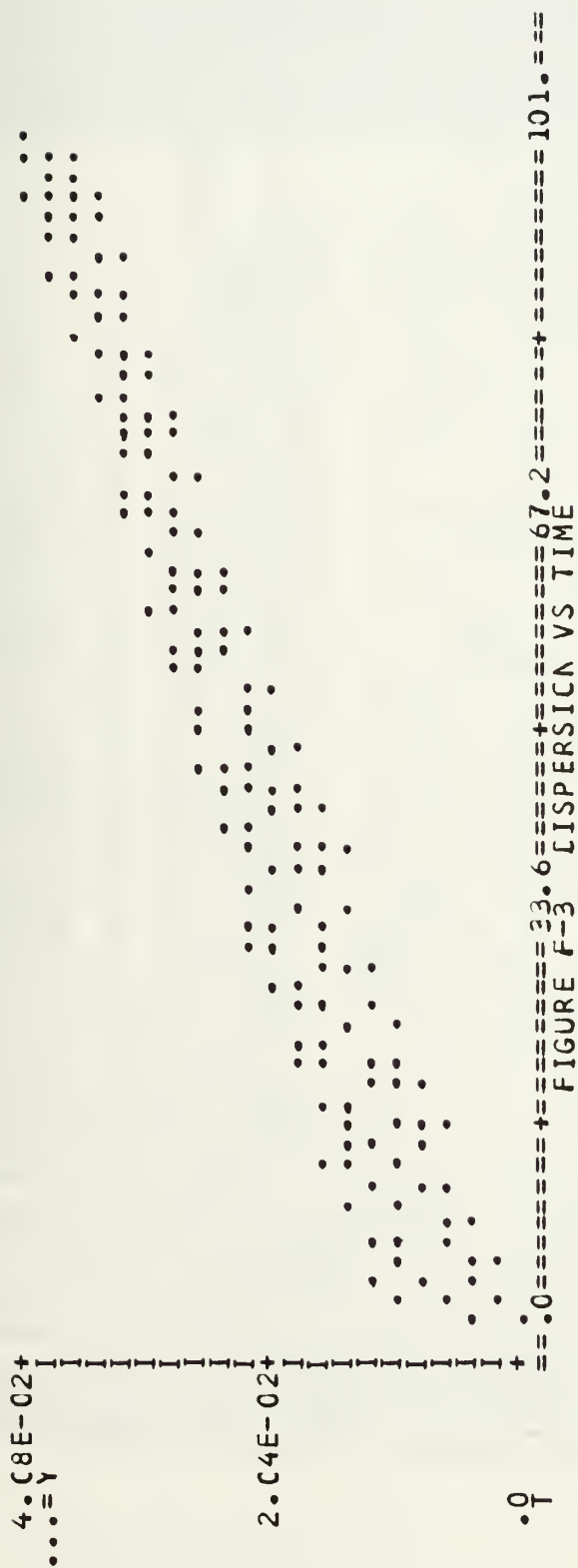
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50	500	202	000	39	0360-01	22	085.	-		
51	500	203	000	38	0400-01	21	451.	-		
52	500	204	000	36	3750-01	20	810.	-		
53	500	205	000	35	1890-01	20	160.	-		
54	500	206	000	35	2650-01	19	503.	-		
55	500	207	000	36	9050-01	18	837.	-		
56	500	208	000	38	8700-01	18	164.	-		
57	500	209	000	39	9810-01	17	482.	-		
58	500	210	000	39	5370-01	16	753.	-		
59	500	211	000	37	9850-01	16	055.	-		
60	500	212	000	36	7360-01	15	389.	-		
61	500	213	000	38	3100-01	14	655.	-		
62	500	214	000	40	1780-01	13	224.	-		
63	500	215	000	40	8440-01	12	466.	-		
64	500	216	000	39	8510-01	11	740.	-		
65	500	217	000	37	728.	37	728.	-		
66	500	218	000	36	552.	36	552.	-		
67	500	219	000	36	144.	36	144.	-		
68	500	220	000	35	708.	35	708.	-		
69	500	221	000	34	872.	34	872.	-		
70	500	222	000	34	431.	34	431.	-		
71	500	223	000	33	533.	33	533.	-		
72	500	224	000	33	527.	33	527.	-		
73	500	225	000	35	2220-01	32	550.	-		
74	500	226	000	36	7570-01	32	109.	-		
75	500	227	000	35	9450-01	31	621.	-		
76	500	228	000	34	4140-01	31	124.	-		
77	500	229	000	32	8040-01	30	1619.	-		
78	500	230	000	31	8130-01	30	107.	-		
79	500	231	000	31	9140-01	29	586.	-		
80	500	232	000	33	1490-01	29	057.	-		
81	500	233	000	35	0760-01	28	520.	-		
82	500	234	000	36	5300-01	27	575.	-		
83	500	235	000	37	9490-01	27	423.	-		
84	500	236	000	37	7260-01	26	862.	-		
85	500	237	000	36	4270-01	26	716.	-		
86	500	238	000	34	7550-01	25	793.	-		
87	500	239	000	33	6250-01	25	131.	-		
88	500	240	000	33	7130-01	24	537.	-		
89	500	241	000	35	0740-01	23	536.	-		
90	500	242	000	37	0650-01	23	327.	-		
91	500	243	000	38	6650-01	22	710.	-		
92	500	244	000	39	0360-01	22	085.	-		
93	500	245	000	38	0400-01	21	451.	-		
94	500	246	000	36	3750-01	20	810.	-		
95	500	247	000	35	1890-01	20	160.	-		
96	500	248	000	35	2650-01	19	503.	-		
97	500	249	000	36	9050-01	18	837.	-		
98	500	250	000	38	8700-01	18	164.	-		
99	500	251	000	39	9810-01	17	482.	-		
00	500	252	000	39	5370-01	16	753.	-		
01	500	253	000	37	9850-01	16	055.	-		
02	500	254	000	36	7360-01	15	389.	-		
03	500	255	000	38	3100-01	14	655.	-		
04	500	256	000	40	1780-01	13	224.	-		
05	500	257	000	40	8440-01	12	466.	-		
06	500	258	000	39	8510-01	11	740.	-		








```

DATA CTE /4F SUM,4H MARY,4H FAR,4HD CU,4FTPUT/
DATA CTC /4F 3 D,4FEG D,4HURIN,4HG BU,4HRNIN,4HG /
DATA CT10 /4H ITE,4FRATE,4H ON,4HCE /
DATA CT11 /4H TER,4HMINA,4HTE A,4HT TE,4HRM X,4HINST,
14HEAD /4HOF T,4HERM,4HX2 /
DATA CT12 /4H 5 D,4HIGIT,4H TIM,4HE PR,4HINT /
INTEGER SYM(19)
DATA SYN /2F10, 2HPC, 2HIM, 2HIP, 2FIS, 2HAA, 2HTC, 2HIB, 2HSS/
12HRJ, 2FVC, 2HMC, 2HAC, 2HRI, 2HRT, 2HRC, 2PRS, 2HMM, 2HNA, 2HSS/
DATA CMFGT /O, 2E, 08359, 1148, 29356, 2460, 62592, 4101, 04587,
15741, 46582, 7381, 88976, 9022, 30971, 10662, 72966, 12303, 14961,
213543, 56555, 15583, 58550, 18044, 61542, 21325, 45932, 24606, 29921,
327887, 13511, 31167, 97900, 34448, 81850, 37725, 65879, 41010, 45865,
444251, 33858, 47572, 17848, 50853, 01837, 54133, 85827, 57414, 65816,
560655, 33806, 63576, 37755/
ASSIGN 167 TO IER
NEXT TWC STATEMENTS ARE MINE
INTEGER R(19), CODE, SS, TYPE, DUMMY
DATA CLUMY/1H /
DO 1 I=1,3833
1 LE(I)=C.
JBURN=1 WITH AEROPACK END WITH 0 IN CCL 8C
2 CALL AEFCF
3 IF (IRSET,NE.0) GO TO 4
DO 3 I=1,856
LE(I)=C.
IS1=955.55
ISP=999.99
TBM=.55559
ISLN=0
J2=1
TSRB=.5555
DENSF=1.
PRESF=1.
TEMPF=1.
CMETM=C.
SL=1.
CONTRCL CARD OPTIONS SET FOR 6DEG,SPIN,FT,STCF TRAJ ON T,FLAT TRAJ
4 REAC (5,159) R,CCDE,SS,TYPE
4 IDGREE(1)=1
IRCT=R(2)
IREDC=F(3)
ITWT=1
IUFLEG=F(5)
IUNIT=1
ISPR=1
IRSET=1

```



```

IF (ID.NE.ICN) GC TC 13
ICN=ICN+10
1C C(2)=AMTCMS*C(2)
C(3)=AMTCMS*C(3)
L=K
DO 11 I=1,7
ATM(L)=C(I)
11 L=L+1
IF (L.LE.693) GC TC 12
WRITE (6,173)
STCP
12 K=K+7
IF (C(1).GE.0.) GO TO 9
ATM(L-7)=ABS(ATM(L-7))
NATM=K-7
GO TO 4
13 WRITE (6,172)
STCP
14 MTEST=C(1)
MTB=C(2)
D=FTOM*C(3)
CGTB=FTCM*C(4)
ATB=FTCM2*C(5)
BTB=FTCM2*C(6)
TWIST=C(7)
15 IF (SS.EQ.DUMMY) GO TO 4
GO TO 34
16 LO=FTCM*C(1)
GE(1)=C(2)
AZC=C(3)
BC=C(4)/ANTCM**2
SL=C(5)
IH2=C(6)
IH3=C(7)
GO TO 15
17 ITC=C(1)
IX1=FTCM*C(2)
IX2=FTCM*C(3)
IX3=FTCM*C(4)
IARV=C(5)
IARH=C(6)
GO TO 15
18 DEIFF=C(1)
PTFF=C(2)
XIDEL=FTCM*C(3)
AZ=C(4)
LAT=C(5)
GO=FTCM*C(6)

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FDU01450
FDU01460
FDU01470
FDU01480
FDU01490
FDU01500
FDU01510
FDU01520
FDU01530
FDU01540
FDU01550
FDU01560
FDU01570
FDU01580
FDU01590
FDU01600
FDU01610
FDU01620
FDU01630
FDU01640
FDU01650
FDU01660
FDU01670
FDU01680
FDU01690
FDU01700
FDU01710
FDU01720
FDU01730
FDU01740
FDU01750
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FDU01780
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FDU01800
FDU01810
FDU01820
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FDU01920

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 2000
 2010
 2020
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 2270
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 2360
 2370
 2380
 2390
 2400

15 GO TO 15
 Q=C(1)
 TF=C(2)
 E=C(3)
 LL=FTCM*(4)
 SL6C=C(5)
 20 GO TO 15
 TI=C(1)
 XI0=FTCM*(2)
 XI MAX=FTCM*(3)
 YI=FTCM*(4)
 ZI=FTCM*(5)
 EXI=FTCM*(6)
 EZI=FTCM*(7)
 21 GO TO 15
 TMCBI=C(1)
 UMCB=FTCM*(2)
 PHMCB=FTCM*(3)
 THMCB=FTCM*(4)
 EUB=FTCM*(5)
 EPB=DTCM*(6)
 ETB=DTCA*(7)
 22 GO TO 15
 R2TBM=FTCM*(1)
 RNE=FTCM*(2)
 AE=FTCM*(3)
 PE=C(4)/FTM2
 RN=FTCM*(5)
 RK=FTCM*(6)
 23 GO TO 15
 QE(1)=C(1)
 IX2=FTCM*(2)
 IU=FTCM*(3)
 AZU=C(4)
 EU=C(5)
 XI MAX=FTCM*(6)
 XI=XIMAX
 AZC=C(7)
 24 GO TO 15
 WSX(1)=FTGMS*(1)
 WSZ=AMTMS*(2)
 WBX=AMTMS*(3)
 WBZ=AMTMS*(4)
 DENSF=C(5)
 PR ESF=C(6)
 TEMFF=C(7)
 CMETM=C.
 J2=1

FDU02410
 FDU02420
 FDU02430
 FDU02440
 FDU02450
 FDU02460
 FDU02470
 FDU02480
 FDU02490
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 FDU02870
 FDU02880

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25  GO TO 15
    IH2B=C(1)/DTOM
    IH3B=C(2)/DTOM
    IFUB=C(3)/FTOM
    CX1=(C(4)/ANTOM**2)/FTCM
    LZ1=C(5)/FTCM
    GO TO 15
26  ISJ=C(1)
    ISP=C(2)
    MF=C(3)
    LE(1)=FTCM*C(4)
    CGTB=FTCM*C(5)
    ATBM=FTCM*C(6)
    MDI=C(7)
    GO TO 15
27  TBMST=C(1)
    TBM=C(2)
    TBST=C(3)
    TB=C(4)
    TL=C(5)
    TDI=C(6)
    TEF=C(7)
    GO TO 15
28  DELTB=C(1)
    PTB=C(2)
    TCE=C(3)
    TCEFF=C(4)
    GO TO 15
29  TSRIST=C(1)
    TSRI=C(2)
    TSRESI=C(3)
    TSREB=C(4)
    RS=FTCM*C(5)
    TSCF=C(6)
    GO TO 15
30  ALCLNG=C(1)
    RACS=C(2)*1000.
    ADQS=C(3)*1000.
    HACAA=C(4)*1000.
    TOCAY=C(5)*1000.
    ISUN=1
    GO TO 15
31  HGIMDP=C(1)/FTOM
    CMEIM=1.
    CODEM=CCE
    DO 32 I=1,162,6
    K=I+4
    READ (5,171) (CMMT(J),J=I,K)
  
```

```

13 IF (CMMT(I).EQ.0..AND.CMMT(I+3).EQ.C..AND.CMMT(I+4).EQ.0.) GO TO 3
L=CMMT(I)+1
IF (L.NE.1+I/6) GO TO 13
CMMT(I)=HGNDP+CMHGT(L)
CMMT(I+5)=.1*CMMT(I+3)
CMMT(I+3)=348.3676356*CMMT(I+4)/CMMT(I+5)
CMMT(I+5)=CMMT(I+5)-273.15
32 NMET=6*L
33 J2=2
GO TO 4
34 IF (Q.EC.0.) Q=1.2
IF (BC.EC.0.) BC=MTBST/D**2
IF (SL.EC.0.) SL6D=1.
IF (SL.EC.0.) SL=1.
GORSQ=GC#RSC
GSC=Q**2
J9=2
MTBM=0.
IF (MF.NE.0.) MTBM=MTB+MF+MDI
TMCB=TMCB1
IF (TMCB.EC.0.) TMCB=TE6
IF (IUFL.EC.NE.0.) J9=1
IYP=1
IF (ICLFE.NE.0.) IYP=0
IF (IUNIT.EC.0.) GO TO 35
PMTCF=APTOF
PDTCM=1.
GO TO 37
35 PMTCF=1.
36 PDTCM=CTCM
ITE=0
IF (IREC.EC.1) ITE=1
IF (CMETN.EC.0.) GCTC 38
J=1
DO 37 I=1,NMET,6
ATM(J)=CMMT(I)
ATM(J+3)=CMMT(I)
ATM(J+4)=CMMT(I+3)
ATM(J+5)=CMMT(I+4)
ATM(J+6)=CMMT(I+5)
AZMWD=CVNTR*(AZ-1.0.*CMMT(I+1))
WS=.5144444444*CMMT(I+2)
ATM(J+1)=-WS*CCS(AZMWD)
ATM(J+2)=WS*SIN(AZMWD)
37 J=J+7
38 NATM=J-1
SPN=TWIST

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IF (ITWT.EQ.0) SPN=UO/(TWIST*D)
Y(10)=T*CPH*SPN
IF (XIC.EQ.C.) XIO=XIDEL
XI=XIO
IF (XICEL.EC.0.) XI=XIMAX
IF (IRELUC.EQ.1) TFN=-TF
ICNP=3
IF (IARV.EQ.0.) AND.IARH.EQ.0.) GC TC 35
IUEL=IAFV
IUAZ=IAFH
GO TO 4C
35 IUEL=QE(1)
4C IUAZ=AZC
CGTBM=CGTE
ATBM=ATE
41 TALPH=0.
IC1=11
ICCT1=11
ICCT2=12
ICCT3=13
ICCT4=14
WRITE (6,197)
I=1
IF (IDGREE(1).EQ.0) GO TO 43
DO 42 J=1,4
CTP(I)=CT1(J)
I=I+1
42 IF (IRCT.EC.0) GC TC 45
DO 44 J=1,4
CTP(I)=CT2(J)
I=I+1
44 IF (IRELUC.EQ.0) GO TO 47
DO 46 J=1,4
CTP(I)=CT3(J)
I=I+1
46 IF (ITWT.EQ.0) GC TC 49
DO 48 J=1,4
CTP(I)=CT4(J)
I=I+1
48 IF (UFLEG.EQ.0) GO TO 51
DO 50 J=1,4
CTP(I)=CT5(J)
I=I+1
50 IF (I+1)
51 IF (ISTIM.EC.0) GO TO 53
DO 52 J=1,4
CTP(I)=CT6(4)
I=I+1
52

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FDU03370
FDU03380
FDU03390
FDU03400
FDU03410
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FDU03780
FDU03790
FDU03800
FDU03810
FDU03820
FDU03830
FDU03840

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53 IF (ISFFT.EQ.0) GO TO 55
54 J=1,4
CTP(I)=CT7(J)
55 I=I+1
56 IF (ISCLT.EQ.0) GC TC 57
57 J=1,4
CTP(I)=CT8(J)
58 I=I+1
59 IF (ISCLR.EQ.0) GO TO 59
60 J=1,4
CTP(I)=CT9(J)
61 I=I+1
62 IF (ITCNC.EQ.0) GC TC 61
63 J=1,4
CTP(I)=CT10(J)
64 I=I+1
65 IF (IXIAYI.EQ.0) GC TO 63
66 J=1,4
CTP(I)=CT11(J)
67 I=I+1
68 IF (ISLIC.EQ.0) GO TO 65
69 J=1,4
CTP(I)=CT12(J)
70 I=I-1
WRITE (6,198) (CTP(J),J=1,I)
ICOTT=C
WRITE (6,178) CCDE
WRITE (6,179)
PR (1)=MTEST
PR (2)=MTEM
PR (3)=MFB
PR (4)=MFI
PR (5)=MCI
PR (6)=D/FIOM
PR (7)=LE(1)/FIOM
PR (8)=CGTBM/FIOM
PR (9)=CCIB/FIOM
PR (10)=ATBM/FIOM2
PR (11)=ATB/FIOM2
PR (12)=ETBM/FIOM2
PR (13)=EL/FIOM
WRITE (6,180) (PR(I),I=1,13)
IF (ITW1.EQ.0) WRITE (6,181)
IF (ITW1.EQ.1) WRITE (6,177)
PR (1)=CE(1)
PR (2)=LC/FIOM
PR (3)=AZ

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FDU003850
FDU003860
FDU003870
FDU003880
FDU003890
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FDU003920
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FDU003940
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FDU003960
FDU003970
FDU003980
FDU003990
FDU004000
FDU004010
FDU004020
FDU004030
FDU004040
FDU004050
FDU004060
FDU004070
FDU004080
FDU004090
FDU004100
FDU004110
FDU004120
FDU004130
FDU004140
FDU004150
FDU004160
FDU004170
FDU004180
FDU004190
FDU004200
FDU004210
FDU004220
FDU004230
FDU004240
FDU004250
FDU004260
FDU004270
FDU004280
FDU004290
FDU004300
FDU004310
FDU004320

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PR (8)=ALCAG
PR (9)=BC#ANTOM**2
PR (10)=SL
PR (11)=SL6D
PR (12)=C
PR (13)=TF
WR ITE (6,188) (PR(1),I=1,13)
WR ITE (6,189)
PR (1)=ITD
PR (2)=IX1/FTOM
PR (3)=IX2/FTOM
PR (4)=IX3/FTOM
PR (5)=TI
PR (6)=XI0/FTOM
PR (7)=XIDEL/FTOM
PR (8)=XIMAX/FTOM
PR (9)=VI/FTOM
PR (10)=ZI/FTOM
PR (11)=EX1/FTOM
PR (12)=EZ1/FTOM
PR (13)=G0/FTOM
WR ITE (6,190) (PR(1),I=1,13)
WR ITE (6,191)
PR (1)=TMCB
PR (2)=LMCB/FTOM
PR (3)=PMCB/DTOM
PR (4)=TFMCB/DTOM
PR (5)=C
PR (6)=ELCB/FTOM
PR (7)=ETE/DTOM
PR (8)=EFB/DTOM
PR (12)=LZ1*FTOM
PR (8)=IF2B*DTOM
PR (9)=IF3B*DTOM
PR (10)=TFUB*FTOM
PR (13)=C
PR T=CX1*FTOM*ANTOM**2
IF (ITCNC.EQ.0) PR(11)=PRT
IF (ITCNC.NE.0) PR(13)=PRT
WR ITE (6,152) (PR(1),I=1,13)
GO TO (66,67), J2
66 WR ITE (6,153)
PR (1)=W3X(1)/AMTOMS
PR (2)=W3Z/AMTOMS
PR (3)=WBX/AMTOMS
PR (4)=WEZ/AMTOMS
PR (5)=CENSF
PR (6)=PRESF

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HDU04410
FDU04420
FDU04430
FDU04440
FDU04450
FDU04460
FDU04470
FDU04480
FDU04490
FDU04500
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FDU04520
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FDU04590
FDU05000
FDU05010
FDU05020
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FDU05200
FDU05210
FDU05220
FDU05230
FDU05240
FDU05250
FDU05260
FDU05270
FDU05280

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PR(7)=TEMPF
WRITE(6,154) (PR(I),I=1,7)
GO TO 65
67 DO 68 I=1,NATM,7
  PR(1)=ATM(I)
  PR(2)=ATM(I+1)/AMTOMS
  PR(3)=ATM(I+2)/AMTOMS
  PR(4)=ATM(I+3)
  PR(5)=ATM(I+4)
  PR(6)=ATM(I+5)
  PR(7)=ATM(I+6)
68 WRITE(6,156) (PR(J),J=1,7)
69 SINLAT=SIN(LAT*CVDTCR)
  COSLAT=COS(LAT*CVDTCR)
  SINAZ=SIN(AZ*CVMTOR)
  COSAZ=COS(AZ*CVMTOR)
  IF (ISUN.EQ.0) GO TO 70
  WPI=AINI(RACS/10000.)
  AFP1=RAINI(AFPI/100.)
  FP2=AFP1-FPI*100.
  RAD=PI/12*(WPI+FP1/60.+FP2/3600.)
  WPI=AINI(RACA/10000.)
  AFP1=HACA-WPI*10000.
  FP1=AINI(AFPI/100.)
  FP2=AFP1-FPI*100.
  HAGD=PI/12*(WPI+FP1/60.+FP2/3600.)
  WPI=AINI(TOCAY/10000.)
  AFP1=TCAY-WPI*10000.
  FP1=AFP1-FPI*100.
  FP2=AFP1-FPI*100.
  TOCAYD=PI/12*(WPI+FP1/60.+FP2/3600.)
  WPI=AINI(ADCS/10000.)
  AFP1=ACCS-WPI*10000.
  FP1=AINI(AFPI/100.)
  FP2=AFP1-FPI*100.
  DECLD=CVLTCR*(WPI+FP1/60.+FP2/3600.)
  DEL=HAGD-RAD
  IF (DEL.LT.0) DEL=DEL+TWOPHI
  DEL=DEL-CVDTOR*ALONG+TCCAYC
  WHAT IS SINCOS SUBROUTINE?
  CALL SINCOS(DECLD,SINC,COSD)
  SINDEL=SIN(DECLD)
  COSL=COS(DECLD)
  PPI=10000.
  IF ERR=C
  CM=0.
7C

```

C C

```

IF (IRCT-EC.1) GC TC 71
LAM(1)=C:
LAM(2)=C:
LAM(3)=C:
GO TO 72
71 LAM(1)=.0001458424*COSLAT*SINAZ
LAM(2)=.0001458424*SINLAT
LAM(3)=.0001458424*COSLAT*CGSAZ
72 JCCE=1
IF (ITCNCE-EQ.0) GO TO 74
JCCE=2
WRITE (6,26C)
CALL PNEST (26, QE(1), 0., TL)
TL=(AINT((TL+.0005)*1000.))/1000.
ICCT1=ICCT1+1
IF (ICCT1-NE.1) GC TO 74
73 WRITE (6,175) UMCB,XI,CCDEM,ICCT1
IEPC=2
CALL SPRINT (Y,CY,1)
GO TO 4
74 I6CP=0
IF (I3LEUR-EQ.0) GC TC 75
ICCT1=ICCT1+100
ICCT2=ICCT2+100
ICCT3=ICCT3+100
ICCT4=ICCT4+100
75 R3TBM=CGTBM-CGTB
R3=0.
TO=MTBM-MTB
RTBM=MTBM*R3TBM/TO
RK2=RK*.5
RK12=R1TBM-RK2*TO
RK12=((FK**2)/12.
R2TESQ=R2TBM**2-RK12*TO**2
BTB=BTBM-TO*R2TBM**2-MTB*R1TBM**2+MTBM*(R1TBM-R3TBM)**2
RTB=LE(1)-CGTB
RTB=LETE-RN
DSC=D*2
D22=MTBST/BC
Y(1)=MTB
Y(2)=TEA
Y(3)=PC
CONS2=(TBST-TBMST)/(TB-TBM)
SINEU=SIN(EL*CVMTOR)
CUSEU=CCS(EL*CVMTOR)
SINAZC=SIN(AZD*CVMTOR)
CGSAZD=COS(AZD*CVMTOR)
SINCCE=SIN(QE(1)*CVMTOR)

```

```

FCLO5170
FCLO51780
HDLO5190
FDLO51900
FDLO51910
FDLO51920
FDLO51930
FDLO51940
FDLO51950
FDLO51960
HDLO51970
FDLO51980
FDLO51990
FDLO5200
FDLO5210
FDLO5220
FDLO5230
FDLO5240
FDLO5250
FDLO5260
HDLO5270
FDLO5280
FDLO5290
FDLO530
FDLO5310
FDLO5320
FDLO5330
FDLO5340
HDLO5350
FDLO5360
FDLO5370
FDLO5380
FDLO5390
FDLO5400
FDLO5410
FDLO5420
FDLO5430
FDLO5440
FDLO5450
FDLO5460
FDLO5470
FDLO5480
FDLO5490
FDLO5500
FDLO5510
FDLO5520
FDLO5530
FDLO5540
HDLO5550
FDLO5560
FDLO5570
FDLO5580
FDLO5590
FDLO5600
FDLO5610
FDLO5620
FDLO5630
FDLO5640
FDLO5650
FDLO5660
FDLO5670
FDLO5680
FDLO5690
FDLO5700
FDLO5710
FDLO5720
FDLO5730
FDLO5740
FDLO5750
FDLO5760
FDLO5770
FDLO5780
FDLO5790
FDLO5800
FDLO5810
FDLO5820
FDLO5830
FDLO5840
FDLO5850
FDLO5860
FDLO5870
FDLO5880
FDLO5890
FDLO5900
FDLO5910
FDLO5920
FDLO5930
FDLO5940
HDLO5950
FDLO5960
FDLO5970
FDLO5980
FDLO5990
FDLO6000
FDLO6010
FDLO6020
FDLO6030
FDLO6040
FDLO6050
FDLO6060
FDLO6070
FDLO6080
FDLO6090
FDLO6100
FDLO6110
FDLO6120
FDLO6130
FDLO6140
FDLO6150
FDLO6160
FDLO6170
FDLO6180
FDLO6190
FDLO6200
FDLO6210
FDLO6220
FDLO6230
FDLO6240

```

```

COSQE=CCS(CQ(1)*CVMTOR)
COSAZU=CCS(AZU*CVMTOR)
SINAZU=SIN(AZU*CVMTCR)
B=BTBM
TRCCNS=MF*CONS2*ISP/IST
DO 76 I=4,9
76 Y(I)=0
  CY(2)=1.0
  IKL=5
  I1=1
  J5=1
  J6=1
  J7=2
  JMZ=0
  IMZ1=0
  IMZ2=0
  IF (UO.NE.O.) GC TC 77
  IF (TBM.LT.C.) GO TO 81
  Y(4)=IX1
  Y(7)=IL*COSEU*COSAZL
  Y(8)=IL*SINEU
  Y(5)=-IL*SINAZU*COSEU
  IF (IX2.EQ.C.) GC TC 82
  Y(5)=IX2
  J8=1
  GO TO 78
77 Y(4)=LL*CCSCE+IX1
  Y(5)=LL*SINCE+IX2
  Y(7)=UC*CCSCE*COSAZC+IU*COSAZU*COSEL
  Y(8)=UC*SINCE+IU*SINEU
  Y(9)=-IL*SINAZU*COSEU+LO*CCSCE*SINAZC
  J8=2
  DY(7)=C
  DY(8)=C
  CY(9)=0
  Y(2)=IL
  IF (ITQ.NE.C.) Y(2)=ITO
78 DELT=1CC.
  PY(1)=C.
  PY(2)=Y(3)
  DPY(1)=1.0
  INN=1
79 WRITE (6,280)
  CALL RKG (DELT,2,DCA,PY,DPY,QQ,INN)
  INN=2
  IF (ABS(PY(1)-Y(5)).LT..00001) GC TC 8C
  IF (PY(1).LT.Y(5)) GO TC 79
  DELT=Y(5)-PY(1)

```

```

FDL06250
FDL06260
FDL06270
FDL06280
FDL06290
FDL06300
FDL06310
FDL06320
FDL06330
FDL06340
FDL06350
FDL06360
FDL06370
FDL06380
FDL06390
FDL06400
FDL06410
FDL06420
FDL06430
FDL06440
FDL06450
FDL06460
FDL06470
FDL06480
FDL06490
FDL06500
FDL06510
FDL06520
FDL06530
FDL06540
FDL06550
FDL06560
FDL06570
FDL06580
FDL06590
FDL06600
FDL06610
FDL06620
FDL06630
FDL06640
FDL06650
FDL06660
FDL06670
FDL06680
FDL06690
FDL06700
FDL06710
FDL06720

```

FDU06730
FDU06740
FDU06750
FDU06760
FDU06770
FDU06780
FDU06790
FDU06800
FDU06810
FDU06820
FDU06830
FDU06840
FDU06850
FDU06860
FDU06870
FDU06880
FDU06890
FDU06900
FDU06910
FDU06920
FDU06930
FDU06940
FDU06950
FDU06960
FDU06970
FDU06980
FDU06990
FDU07000
FDU07010
FDU07020
FDU07030
FDU07040
FDU07050
FDU07060
FDU07070
FDU07080
FDU07090
FDU07100
FDU07110
FDU07120
FDU07130
FDU07140
FDU07150
FDU07160
FDU07170
FDU07180
FDU07190
FDU07200

```

80  GO TO 75
    Y(3)=PY(2)
81  GO TO (E2,83), J8
    DELT=DELTB
    TIME=0.
    I2=1
    I3=1
    NEG=2
82  GO TO 135
    DELT=DELTB
    TIME=TL
    Y(2)=0.
    I2=2
    I3=2
    I4=1
    I5=1
    I6=1
    NEG=8
83  GO TO 135
    I3=3
    I4=2
    I6=2
    I7=1
    I8=1
    I9=1
    NEX=1
    J6=1
    J2=2
    I5=1
    NEG=16
    KI=0
    IFIRST=1
    DELT=DELTB
    IF (TDI.LE.C.) GO TO 84
    CELT=DELTFF
    I4=3
    I5=2
84  TIME=TCF+ITO
    D3=DSC#D
    L4=D3#C
    EER=CVMTOR#IUAZ
    SINEA=SIN(EAR)
    COSSEA=CCS(EAR)
    SINEE=SIN(EER)
    COSSEE=CCS(EER)
    Y(14)=CCSEE#COSEA
    Y(15)=SINEE

```

```

Y(16)=CCSEE*SINEA
ANX=0
ISPI=0
IF (Y(1C).LE..0) GC TC 85
A=ATBM
ANX=Y(1C)*A
CONS3=(ATBM-ATB)/(MTBM-MTB)
CTS=(TSFEST-TSRIST)/(TSRB-TSRI)
GRS=GC*RS
RNESQ2=RNE*2*.5
ISPI=1
I1=2
I8=2
NEG=16
85 IF (ITCNCE.EQ.0) GC TC 86
   WRITE (6,270)
   CALL PNEST (28, QE(1), 0., IH3)
   WRITE (6,270)
   CALL PNEST (20, QE(1), 0., BC)
   BC=BC/ANTUM**2
86 BIF2=B*IF2
   Y(11)=ANX*Y(14)-BIH2*SINEE*COSEA-B*IF3*SINEA
   Y(12)=ANX*Y(15)+BIH2*CCSEE
   Y(13)=ANX*Y(16)-BIF2*SINEE*SINEA+B*IH3*COSEA
   DY(7)=0.
   DY(8)=C.
   DY(9)=0.
   ALPE=0.
   ALPQ1=C.
   ALPQ2=C.
   ALPQ3=C.
   T45(1)=CE(1)
   T45(2)=IH2
   T45(3)=IH3
   T45(4)=IF
   T45(5)=C.
   T45(6)=SL
   T45(7)=C
   T45(8)=C*PMTOF
   T45(9)=CCCE
   T45(10)=ICCT4
   T45(11)=IL*GE*TE6) GO TO 89
   DO 87 I=1,10
   J=ITIT+I+2659
   TJ(J)=T45(I)
   ITIT=ITIT+10
   I6DP=1
87 IF (I3LEUR.EQ.0) GC TC 139

```

```

FDU07210
FDU07220
FDU07230
FDU07240
FDU07250
FDU07260
FDU07270
FDU07280
FDU07290
FDU07300
FDU07310
FDU07320
FDU07330
FDU07340
FDU07350
FDU07360
FDU07370
FDU07380
FDU07390
FDU07400
FDU07410
FDU07420
FDU07430
FDU07440
FDU07450
FDU07460
FDU07470
FDU07480
FDU07490
FDU07500
FDU07510
FDU07520
FDU07530
FDU07540
FDU07550
FDU07560
FDU07570
FDU07580
FDU07590
FDU07600
FDU07610
FDU07620
FDU07630
FDU07640
FDU07650
FDU07660
FDU07670
FDU07680

```

```

D22=MTJST/BC
I6CP=0
IF (Y(10).GT..0) GC TO 88
I7=2
I8=3
NEG=9
GO TO 135
88 ISPI=0
I7=1
I8=4
I9=2
NEG=10
GO TO 135
89 IF (I3DBLR.NE.0) GC TO 90
ICCT1=ICCT1+100
ICCT2=ICCT2+100
ICCT3=ICCT3+100
ICCT4=ICCT4+100
I45(10)=ICCT4
I45(5)=EC/AMTO IN**2
90 DO 91 I=1,10
J=ITTI+2699+I
IJJ(J)=I45(I)
ITTI=ITTI+10
Y(I)=MIE
DO 92 I=1,16
BURN(I)=Y(I)
GO TO 114
93 CONTINUE
IEPD=5
WRITE (6,290)
CALL SPINT (Y,CY,1)
DELT=DELTB
PTIME=PTB
TPRINT=Y(2)+PTB
TIME=TIME
I3=4
J6=2
IF (TCI.GT.0.) GC TC 94
GO TO 140
DELT=DELTFF
94 I3=5
TIME=TCI
GO TO 140
95 IF IRST=0
JB LRN=2
INN=1

```

```

FDU07690
FDU07700
FDU07710
FDU07720
FDU07730
FDU07740
FDU07750
FDU07760
FDU07770
FDU07780
FDU07790
FDU07800
FDU07810
FDU07820
FDU07830
FDU07840
FDU07850
FDU07860
FDU07870
FDU07880
FDU07890
FDU07900
FDU07910
FDU07920
FDU07930
FDU07940
FDU07950
FDU07960
FDU07970
FDU07980
FDU07990
FDU08000
FDU08010
FDU08020
FDU08030
FDU08040
FDU08050
FDU08060
FDU08070
FDU08080
FDU08090
FDU08100
FDU08110
FDU08120
FDU08130
FDU08140
FDU08150
FDU08160

```

```

I3=6
I4=2
I5=1
DELT=DELTB
GO TO 140
96 JBURN=1
IEPD=5
WRITE (6,290)
CALL SPINT (Y,DY,1)
TIME=TE
IF (ABS(TCI-TPRINT).LE..00001) GC TC 97
GO TO 14C
97 TPRINT=TPRINT+PTIME
GO TO 140
98 I3=7
I5=3
DELT=DELTFF
IF (TB.EC.TMCB) GO TO 100
JBURN=3
GO TO 135
99 IEPD=5
WRITE (6,290)
CALL SPINT (Y,DY,1)
TIME=TMCE
I3=5
GO TO 140
100 IFIRST=C
JBURN=4
GO TO 135
101 JBURN=1
IEPC=5
WRITE (6,290)
CALL SPINT (Y,DY,1)
DELT=DELTB
TIME=TEC
I3=8
J6=1
IF (TDI.GT.0.) GO TC 104
IF (ITE.EQ.1) GO TC 103
102 IF (TMCE.EQ.TE6) GC TC 105
GO TO 14C
103 NEX=2
GO TO 148
104 DELT=DELTFF
GO TO 102
105 IF (ITCNCE.NE.0) GC TC 106
ICCT=0

```

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FDU08170
FDU08180
FDU08190
FDU08200
FDU08210
FDU08220
FDU08230
FDU08240
FDU08250
FDU08260
FDU08270
FDU08280
FDU08290
FDU08300
FDU08310
FDU08320
FDU08330
FDU08340
FDU08350
FDU08360
FDU08370
FDU08380
FDU08390
FDU08400
FDU08410
FDU08420
FDU08430
FDU08440
FDU08450
FDU08460
FDU08470
FDU08480
FDU08490
FDU08500
FDU08510
FDU08520
FDU08530
FDU08540
FDU08550
FDU08560
FDU08570
FDU08580
FDU08590
FDU08600
FDU08610
FDU08620
FDU08630
FDU08640

```

```

106 IF (TMCE.EQ.TE6) GC TC 107
   IEPD=5
   WRITE (6,290)
   CALL SPRINT (Y,DY,1)
107 GO 108 I=1,16
108 BURN(I)=Y(I)
109 IF (I3CBUR.EQ.0.AND.1TONQE.EQ.0) GC TO 110
   GO TO 112
110 ICCTT=ICCTT+1
   IF (ICCTT.NE.11) GO TO 111
   WRITE (6,175) UMCB,XI,CCDEM,ICCT1
   IEPD=2
   WRITE (6,290)
   CALL SPRINT (Y,DY,1)
   GO TO 167
111 ICCT1=ICCT1+100
   ICCT2=ICCT2+100
   ICCT3=ICCT3+100
   ICCT4=ICCT4+100
112 T45(5)=BC/AMTOIN**2
   T45(6)=SL
   T45(10)=ICCT4
   DO 113 I=1,10
     J=I+1
     T1T=I+2659
     T1T=I+1
     T1T=I+1
     DY(7)=0.
     DY(8)=C.
     CY(9)=0.
     ALPE=0.
     TALLPH=C.
114 IF (I3CF.EQ.0) GO TO 115
   IKL=12
115 D22=MTBST/BC
   DELT=DETF
   PTIME=PTFF
   Y(1)=MTE
   CY(1)=0.
   TPRINT=ICFF
   IF (TPRINT.EQ.0.) TPRINT=PTFF+ITO
   I4=3
   I5=3
   J6=2
   NE X=1
   K1=0
   NEG=16
   I6DP=0
   IF (ICGREE(1).EQ.0) GO TO 116

```

```

FDU08650
FDU08660
FDU08670
FDU08680
FDU08690
FDU08700
FDU08710
FDU08720
FDU08730
FDU08740
FDU08750
FDU08760
FDU08770
FDU08780
FDU08790
FDU08800
FDU08810
FDU08820
FDU08830
FDU08840
FDU08850
FDU08860
FDU08870
FDU08880
FDU08890
FDU08900
FDU08910
FDU08920
FDU08930
FDU08940
FDU08950
FDU08960
FDU08970
FDU08980
FDU08990
FDU09000
FDU09010
FDU09020
FDU09030
FDU09040
FDU09050
FDU09060
FDU09070
FDU09080
FDU09090
FDU09100
FDU09110
FDU09120

```

```

I6CP=1
J5=2
INN=1
IUSA=1
JJ1=1
TS1=0.140
GO TO 140
116 IF (Y(10).GT.0.) GC TC 117
I7=2
I8=3
NEG=9
GO TO 118
117 IF (ISFI.EQ.1) Y(10)=HCX/A
I7=1
I8=4
I9=2
NEG=10
INN=1
IUSA=1
JJ1=2
WRITE RKC (6,28C)
CALL RKC (DELT,NEQ,CER,Y,DY,QQ,INN)
119 INN=2
IEXIT=1
IF (I6CP.EQ.1) GO TC 121
I1=Y(10)/TWOPHI
GO TO 122
121 I1=0
IF (A.GT.0.) T1=HD X/(TWCPHI*A)
IF (T1.LT.20.) GC TO 125
IF (VT.EC.C.OR.Y(2).LT.TL) GO TO 125
IF (A.EC.C.) GO TO 125
CAPM=KNCENSDSQ*D33/B
CAPP=TWCPHI*T1*D*A/(B*VT)
I1=KDB+CKCB
IF (I6DF.EC.1) T1=KDE+DKCBA
I2=DENS*D33/Y(1)
CAPH=T2*(KL-KT)*(Y(1)*DSQ/A))
CAPH=T2*(KL-T1+KH*(Y(1)*DSQ/B))
T1=2.*CAPM*(2.*CAPT-CAPP**2)
T2=4.*CAPM*(CAPH+T1*T2)
T3=SIN(.5*ATAN2(T1,T2))
I1=SQRT(T1**2+T2**2)
PP1=.5*(CAPP+T1*T3)
PP2=.5*(CAPP-T1*T3)
IF (ABS(PP1).GE.ABS(PP2)) GO TO 123

```

```

FDU05130
FDU09140
FDU05150
FDU05160
FDU09170
FDU05180
FDU05190
FDU05200
FDU05210
FDU09220
FDU05230
FDU05240
FDU05250
FDU05260
FDU05270
FDU05280
FDU05290
FDU09300
FDU05310
FDU05320
FDU09330
FDU05340
FDU05350
FDU05360
FDU05370
FDU05380
FDU05390
FDU05400
FDU05410
FDU05420
FDU05430
FDU05440
FDU05450
FDU05460
FDU05470
FDU05480
FDU05490
FDU05500
FDU05510
FDU05520
FDU05530
FDU05540
FDU05550
FDU05560
FDU05570
FDU05580
FDU05590
FDU05600

```

```

123 IF (Y(2)-NE.TL) GO TO 124
    T1=PP1
    PP1=PP2
    PP2=T1
    PRPP1=PP1
    PRPP2=PP2
    PP1=10000.
    PP2=PP1
    PP1=PP2
    PP2=PP1
    PP1=PP2
    PP2=PP1
    GO TO 125
124 T1=DELTA*V T/D
    PP1=(FF1-PRPP1)/T1
    PRPP1=PP1
    PP2=(FF2-PRPP2)/T1
    PRPP2=PP2
    GO TO (126,141), IEXIT
125 IF (ISTIM.EC.0) GO TO 128
126 IF (ABS(T1-Y(2)).LE.00001) GO TO 130
    IF (K1.EC.1) GO TO 127
    IF (Y(2)-GT.T1) GO TO 127
    GO TO 145
127 DELT=T1-Y(2)
    K1=1
    GO TO (140,119), JJ1
128 IF (IXIAYI.EQ.0) GO TO 131
    IF (ABS(XI-Y(4)).LE.00001) GO TO 130
    IF (K1.EC.1) GO TO 129
    IF (Y(4)-GT.XI) GO TO 129
    GO TO 145
129 DELT=(XI-Y(4))/Y(7)
    K1=1
    GO TO (140,119), JJ1
130 IF (XIEL.EC.0) GO TO 137
    IF (ABS(XIMAX-XI).LT.(XIDEL/10.)).OR.XI.GT.XIMAX) GO TO 137
    IEFC=5
    WRITE (6,290)
    CALL SPRT(Y,DY,1)
    XI=XIDEL*XI
    DELT=DELTB
    K1=0
    IF (I5.EC.4) GO TO 145
    DELT=DELTFF
    GO TO 145
131 YP=Y(5)
    IF (IYP.GT.0) YP=EC
    IF (Y(2).EQ.0) GO TO 132
    IF (ABS(YP-YI).LE.00001) GO TO 137

```

```

FCU05610
FCU05620
FCU05630
FCU05640
FCU05650
FCU05660
FCU05670
FCU05680
FCU05690
FCU05700
FCU05710
FCU05720
FCU05730
FCU05740
FCU05750
FCU05760
FCU05770
FCU05780
FCU05790
FCU05800
FCU05810
FCU05820
FCU05830
FCU05840
FCU05850
FCU05860
FCU05870
FCU05880
FCU05890
FCU05900
FCU05910
FCU05920
FCU05930
FCU05940
FCU05950
FCU05960
FCU05970
FCU05980
FCU05990
FCU10000
FCU10010
FCU10020
FCU10030
FCU10040
FCU10050
FCU10060
FCU10070
FCU10080

```

```

132 IF (K1.EQ.1) GO TO 136
133 GO TO (133,135), J5
134 IF (Y(8).GE.0.) GO TO 134
WR ITE (6,176) CODE,ICOT1
IEPC=3
WR ITE (6,250)
CALL SPRINT (Y,DY,1)
GO TO 4
134 IF (YP.LI.YI) GO TC 145
GO TO 136
135 IF (Y(8).GT.0.) GO TO 145
IF (YP.GI.YI) GO TO 145
136 DELT=(YI-YP)/Y(8)
K1=1
GO TO (140,119), JJ1
137 IEPC=5
NEX=4
J7=1
IF (ITE.EQ.1) GO TC 138
WR ITE (6,250)
CALL SPRINT (Y,DY,1)
GO TO 4
138 NEX=5
J7=2
WR ITE (6,250)
CALL SPRINT (Y,DY,1)
GO TO 152
139 INN=1
IUSA=2
JJ1=1
WR ITE RKC (DELT,NEQ,CER,Y,DY,QQ,INN)
INN=2
IEXIT=2
GO TO 120
141 GO TO (142,56,55,101), JBURN
142 GO TO (143,126), J5
143 IF (ABS(Y(2)-TIME).LE..00001)GOTC(82,83,53,100,95,98,100,105,
110,11), I3
IF (Y(2)+DELT.GT.TIME) GCTO 1443
IF (Y(2)+DELT.LT.TIME+.00001) GCTO 144
DELT=TIME-Y(2)-10.E-15*TIME
GOTC (140,119), JJ1
GO TO 126
144 IF (NEQ.GI.5) GO TO 146
145 GO TO (140,146,119), J6
146 IF (ABS(Y(2)-TPRINT).LE..00001) GC TC 147
K2=0
IF (Y(2)+DELT.LI.TPRINT) GC TO (140,119), JJ1

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FDU10090
FDU10100
FDU10110
FDU10120
FDU10130
FDU10140
FDU10150
FDU10160
FDU10170
FDU10180
FDU10190
FDU10200
FDU10210
FDU10220
FDU10230
FDU10240
FDU10250
FDU10260
FDU10270
FDU10280
FDU10290
FDU10300
FDU10310
FDU10320
FDU10330
FDU10340
FDU10350
FDU10360
FDU10370
FDU10380
FDU10390
FDU10400
FDU10410
FDU10420
FDU10430
FDU10440
FDU10450
FDU10460
FDU10470
FDU10480
FDU10490
FDU10500
FDU10510
FDU10520
FDU10530
FDU10540
FDU10550
FDU10560

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K2=1
SQC=DEL7
DELI=TPRINT-Y(2)
GO TO (140,119), JJ1
147 IEPD=5
WRITE (6,290)
CALL SFRINT (Y,DY,1)
TPRINT=TPRINT+PTIME
IF (K2.EC.0) GO TO (140,119), JJ1
DELT=SCC
K2=0
GO TO (140,119), JJ1
148 LN=LN/PNTOF
PHI=PHI*CTGM/PDTCM
THETA=THETA*DTOM/PCTCM
TO=UMCE-LN
T1=PHMCE-PHI
T2=THMCE-THETA
IF (TFN.LT.0.) GO TO 149
T3=T0*(TFN-TF)/(UNN-UN)
T4=T1*(F3N-IH3)/(PHIN-PHI)
T5=T2*(F2N-IH2)/(THETAN-THETA)
GO TO 150
149 T3=T0*1FLB
T4=T1*1F3B
T5=T2*1F2B
TFN=ABS(TFN)
150 IF (ABS(TO).LT.EUB.AND.ABS(T1).LT.EPB.AND.AFS(T2).LT.ETB) GO TO 151
TFN=TF
H2N=IH2
H3N=IH3
UNN=UN
PHIN=PHI
THETAN=THETA
TF=TFN+T3
IH2=H2N+T5
IH3=H3N+T4
ICCTT=ICCTT+1
IF (ICCTT.EQ.10) GO TO 73
ICCT1=ICCT1+10
ICCT2=ICCT2+10
ICCT3=ICCT3+10
ICCT4=ICCT4+10
GO TO 72
151 NE X=1
IF (IMCE.EC.TE6) GO TO 105
GO TO (140,119), JJ1

```

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HDL1C570
HDL1C580
HDL1C590
HDL1C600
HDL1C610
HDL1C620
HDL1C630
HDL1C640
HDL1C650
HDL1C660
HDL1C670
HDL1C680
HDL1C690
HDL1C700
HDL1C710
HDL1C720
HDL1C730
HDL1C740
HDL1C750
HDL1C760
HDL1C770
HDL1C780
HDL1C790
HDL1C800
HDL1C810
HDL1C820
HDL1C830
HDL1C840
HDL1C850
HDL1C860
HDL1C870
HDL1C880
HDL1C890
HDL1C900
HDL1C910
HDL1C920
HDL1C930
HDL1C940
HDL1C950
HDL1C960
HDL1C970
HDL1C980
HDL1C990
HDL11000
HDL11010
HDL11020
HDL11030
HDL11040

```

```

152 IF (IXIAYI.EQ.0) GC TC 154
   YP=EC
   IF (IYF.EQ.0) YP=Y(5)
   IF (ABS(VI-YP).LE.EX1) GO TC 165
153 YP=Y(5)
   IF (IYF.NE.0) YP=EC
   TO=YI-YP
   XYI=Y P
   GO TO 156
154 IF (ABS(Y(4)-XI).LE.EX1) GO TO 165
155 TO=XI-Y(4)
   XYI=Y(4)
156 T2=ZI-Y(6)
   T1=TO*CX1
   T3=T2*LZ1
157 XM=Y(4)
   IF (IXIAYI.EQ.0) GO TO 158
   YP=EC
   IF (IYF.EQ.0) YP=Y(5)
   XM=YP
158 IF (JCCF-1) 159,159,160
159 CM=BC
   BC=BC+T1
   GO TO 161
160 CM=CE(1)
   CE(1)=CE(1)+T1
   IUEL=QE(1)
161 SLN=SL
   ZM=Y(6)
   SL=SL+T1
   IF (I3CFUR.EQ.0.ANC.ITONQE.EQ.0) GO TO 162
   IF N=-TF
   Y(10)=SFN*TWOPHI
   GO TO 162
162 DO 163 I=1,16
163 Y(I)=PLFN(I)
   GO TO 165
164 CQE=QE(1)
   IF (JCCF.EQ.1) CQE=BC
   T1=TO*(CM-CQE)/(XM-XYI)
   T3=0
   IF (ABS(ZM-Y(6)).LT.0.00000001) GO TC 157
165 T3=T2*(SLM-SL)/(ZM-Y(6))
   GO TO 157
   IF (ABS(Y(6)-ZI).LT.EZ1) GC TO 166
   IF (IXIAYI.EQ.0) GO TO 155
   GO TO 153

```



```

5 IF (TST.LE.0.) GC TC 12
6 TSTAR=TR#TF+(PE-PA)#AE
  V2=Y(8)
  VTSQ=V1**2+V2**2+V3**2
  VT=SQR(VTSQ)
  MACH=VT/VAS
  IF (I6DF.EQ.1) GO TC 7
  GO TO (15,19,20,13), I5
7 VDCIX=V1*Y(14)+V2*Y(15)+V3*Y(16)
  COSA=VDCIX/VT
  IF (ABS(COSA).LE.1.0005) GO TO 8
  WRITE (6,55) Y(2),CCSA,ICODE,ICCT1
  GO TO IER,(56)
8 IF (ABS(CCSA).LE.1.) GC TO 10
  IF (COSA.LT.0.) GO TO 9
  COSA=1.
  ALPHA=C.
  ALPHA=1.145926535
9 GO TO 11
  ALPHA=1.145926535
  ARCCS=AS.AFCCCS
  ALPHA=ARCCS(COSA)
10 ALFSQ=ALPHA**2
  TALPH=ALPSC
  GO TO (15,19,20,13), I5
12 TSTAR=0.
  DY(1)=C.
  GO TO 6
13 V1=Y(7)-WSX(1)
  V3=Y(9)-WSZ
  GO TO 5
14 V1=Y(7)-WBX
  V3=Y(9)-WBZ
  GO TO 5
15 WRITE (6,57)
  CALL PNEST(2,MACH,TALPH,KDB)
  GO TO (16,21), I6
16 WRITE (6,57)
  CALL PNEST(9,MACH,TALPH,F)
  F=FTCN
  TO=(GC#TSTAR-DENS*C22*KDB*VTSQ)/Y(1)-GO*SINCE-F*COSCE
  DY(9)=0
  IF (TC.GT.0.) GO TC 17
  DY(7)=C.
  DY(8)=C.
  GO TO 18
17 DY(7)=TC#CUSQE

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C

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FDU12570
FDU12580
FDU12590
FDU13000
FDU13010
FDU13020
FDU13030
FDU13040
FDU13050
FDU13060
FDU13070
FDU13080
FDU13090
FDU13100
FDU13110
FDU13120
FDU13130
FDU13140
FDU13150
FDU13160
FDU13170
FDU13180
FDU13190
FDU13200
FDU13210
FDU13220
FDU13230
FDU13240
FDU13250
FDU13260
FDU13270
FDU13280
FDU13290
FDU13300
FDU13310
FDU13320
FDU13330
FDU13340
FDU13350
FDU13360
FDU13370
FDU13380
FDU13390
FDU13400
FDU13410
FDU13420
FDU13430
FDU13440

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```

18 DY(8)=TC*SINQE
   DY(4)=Y(7)
   DY(5)=Y(8)
   DY(6)=Y(9)
   GO TO 33
19 DY(1)=MLI/(TL-TDI)
20 WRITE (6,57)
   CALL PNEST (4, MACH, TALPH, KCB)
21 TO=Y(5)+REARTH
   R=SCRT(Y(4)**2+TO**2+Y(6)**2)
   T1=GORS(C/R)**3
   G1=T1*Y(4)
   G2=T1*TC
   G3=T1*Y(6)
   NU1=-LAM(1)*Y(8)-LAM(2)*Y(9)
   NU2=LAM(1)*Y(7)+LAM(3)*Y(9)
   NU3=LAM(2)*Y(7)-LAM(3)*Y(8)
   T4=GC*TSSTAR
   GO TO (22,27), I7
22 WRITE (6,57)
   CALL PNEST (3, MACH, TALPH, DKDB)
   DKDBA=DKDB*ALPSQ
   T1=DENS*CC22
   T2=DENS*CC33
   T3=DENS*DSQ
   WRITE (6,57)
   CALL PNEST (IKL, MACH, TALPH, KL)
   CALL PNEST (IO, MACH, TALPH, KM)
   RE=RETE-R3
   XCG=LE(1)-RE
   TO=(XCGIE-XCC)/D
   KM=KM-TO*(KL+KDB)
   GO TO (23,27), I5
23 T1=-T1*(KCB+DKDBA)*VT
   WRITE (6,57)
   CALL PNEST (6, MACH, TALPH, KS)
   T3=T10*KCS*VT/B
   X1CH1=Y(15)*Y(13)-Y(16)*Y(12)
   X2CH2=Y(16)*Y(11)-Y(14)*Y(13)
   X3CH3=Y(14)*Y(12)-Y(15)*Y(11)
   RT=RTIE-R3
   CALL PNEST (8, MACH, TALPH, KH)
   T11=DENS*DD44
   T7=-DY(1)*RE*RT
   DY(10)=C.
   HDX=0.
   V1CX1=V2*Y(16)-V3*Y(15)
   V2CX2=V3*Y(14)-V1*Y(16)

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FDU13450
FDU13460
FDU13470
FDU13480
FDU13490
FDU13500
FDU13510
FDU13520
FDU13530
FDU13540
FDU13550
FDU13560
FDU13570
FDU13580
FDU13590
FDU13600
FDU13610
FDU13620
FDU13630
FDU13640
FDU13650
FDU13660
FDU13670
FDU13680
FDU13690
FDU13700
FDU13710
FDU13720
FDU13730
FDU13740
FDU13750
FDU13760
FDU13770
FDU13780
FDU13790
FDU13800
FDU13810
FDU13820
FDU13830
FDU13840
FDU13850
FDU13860
FDU13870
FDU13880
FDU13890
FDU13900
FDU13910
FDU13920

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V3 CX3=V1*Y(15)-V2*Y(14)
DO 24 I=7,9
DY(I)=C
24 DY(I+4)=0
XD X=Y(14)**2+Y(15)**2+Y(16)**2
IF (XCX*LE.1.0005) GO TO (25,26,28,30), I8
WRITE (6,54) Y(2), XCX, CCDE, ICOTI
GO TO IER, (56)
25 T2=T2*KL*SL6D
T5=T10*KH*V1
T6=T11*KH*V1
DY(7)=(T1*V1+T2*(VTSQ*Y(14)-VDOIX*V1)+T3*X1CH1+T4*Y(14))/Y(1)-G1
1 DY(8)=(T1*V2+T2*(VTSQ*Y(15)-VDOIX*V2)+T3*X2CH2+T4*Y(15))/Y(1)-G2
1 +NU2*Y(8)
1 DY(9)=(T1*V3+T2*(VTSQ*Y(16)-VDOIX*V3)+T3*X3CH3+T4*Y(16))/Y(1)-G3
1 +NU3*Y(9)
DY(4)=Y(7)
DY(5)=Y(8)
DY(6)=Y(9)
HD XX1=FCX*Y(14)
HD XX2=FCX*Y(15)
HD XX3=FCX*Y(16)
DY(11)=T5*V1CX1+(T6*(HDXX1-Y(11))-T7*(Y(11)-HDXX1))/B+DY(11)
DY(12)=T5*V2CX2+(T6*(HDXX2-Y(12))-T7*(Y(12)-HDXX2))/B+DY(12)
DY(13)=T5*V3CX3+(T6*(HDXX3-Y(13))-T7*(Y(13)-HDXX3))/B+DY(13)
DY(14)=-X1CF1/B
DY(15)=-X2CF2/B
DY(16)=-X3CF3/B
GO TO 33
26 HD X=Y(11)*Y(14)+Y(12)*Y(15)+Y(13)*Y(16)
T9=HD X/A
WRITE (6,57)
CALL PNEST (13, MACF, TALPH, KF)
KF=KF*T9*Y(1)
CALL PNEST (44, MACF, TALPH, KTA)
KTA=KTA*ALP SQ
CALL PNEST (15, MACF, TALPH, KT)
KT=KT+KTA
TK=T11*T9*KT
CALL PNEST (41, MACF, TALPH, KLA)
KLA=KLA*ALP SQ
KL=KL+KLA
CALL PNEST (42, MACF, TALPH, KMA)
KMA=KMA*ALP SQ
KM=KM+KMA
CALL PNEST (43, MACF, TALPH, KHA)
KHA=KHA*ALP SQ

```

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FDU1 3530
FDU1 3540
FDU1 3550
FDU1 3560
FDU1 3570
FDU1 3580
FDU1 3590
FDU1 4000
FDU1 4010
FDU1 4020
FDU1 4030
FDU1 4040
FDU1 4050
FDU1 4060
FDU1 4070
FDU1 4080
FDU1 4090
FDU1 4100
FDU1 4110
FDU1 4120
FDU1 4130
FDU1 4140
FDU1 4150
FDU1 4160
FDU1 4170
FDU1 4180
FDU1 4190
FDU1 4200
FDU1 4210
FDU1 4220
FDU1 4230
FDU1 4240
FDU1 4250
FDU1 4260
FDU1 4270
FDU1 4280
FDU1 4290
FDU1 4300
FDU1 4310
FDU1 4320
FDU1 4330
FDU1 4340
FDU1 4350
FDU1 4360
FDU1 4370
FDU1 4380
FDU1 4390
FDU1 4400

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```

KH=KH+KFA
CALL PNEST (17,MACH,TALPH,KA)
KA=KA*TI1*VT*9
CALL PNEST (24,MACH,TALPH,KE)
KE=KE*TI10*E*VT*SQ
AM=(Y(2)-TSRI)*CTS+TSRIST
CALL PNEST (25,AM,TALPH,TS)
TS=TS*CTS*TS*TS*GCRS
TO=-KA+KE+TS
TI2=DY(1)*RNESQ2*TS
DY(7)=-KF*VICX1
DY(8)=-KF*V2CX2
DY(9)=-KF*V3CX3
TO*TI2=TC*TI2
DY(11)=TK*(VDOITX*Y(14)-V1)+Y(14)*TOTI2
DY(12)=TK*(VDOITX*Y(15)-V2)+Y(15)*TOTI2
DY(13)=TK*(VDOITX*Y(16)-V3)+Y(16)*TOTI2
GO TO 25
27 GK TO (25,26,28,30), 18
28 DK DB=0.
DY(7)=0.
DY(8)=0.
DY(9)=0.
29 TO=-DEN*CTS*LC22*(KDB+DKDB)*VT
CU*SAE=CCS(SCRT(ALPE))
CO*SAVT=CCSAE/VT
ALP1=I4*(V1*CO*SAVT+ALPQ1)
ALP2=I4*(V2*CO*SAVT+ALPC2)
ALP3=I4*(V3*CO*SAVT+ALPC3)
DY(7)=(ALP1+TO*V1)/Y(1)-G1+NU1+DY(7)
DY(8)=(ALP2+TO*V2)/Y(1)-G2+NU2+DY(8)
DY(9)=(ALP3+TO*V3)/Y(1)-G3+NU3+DY(9)
DY(4)=Y(7)
DY(5)=Y(8)
DY(6)=Y(9)
GO TO 30
30 WRITE (6,57)
CALL PNEST (13,MACH,TALPH,KF)
CALL PNEST (15,MACH,TALPH,KT)
CALL PNEST (44,MACH,TALPH,KTO)
KT=KT+KTC*ALPE
CALL PNEST (42,MACH,TALPH,KMA)
KM=KM+KMA*ALPE
CALL PNEST (41,MACH,TALPH,KLA)
KL=KL+KLA*ALPE
CALL PNEST (43,MACH,TALPH,KHA)
KH=KH+KFA*ALPE

```

```

FDU1 4410
FDU1 4420
FDU1 4430
FDU1 4440
FDU1 4450
FDU1 4460
FDU1 4470
FDU1 4480
FDU1 4490
FDU1 4500
FDU1 4510
FDU1 4520
FDU1 4530
FDU1 4540
FDU1 4550
FDU1 4560
FDU1 4570
FDU1 4580
FDU1 4590
FDU1 4600
FDU1 4610
FDU1 4620
FDU1 4630
FDU1 4640
FDU1 4650
FDU1 4660
FDU1 4670
FDU1 4680
FDU1 4690
FDU1 4700
FDU1 4710
FDU1 4720
FDU1 4730
FDU1 4740
FDU1 4750
FDU1 4760
FDU1 4770
FDU1 4780
FDU1 4790
FDU1 4800
FDU1 4810
FDU1 4820
FDU1 4830
FDU1 4840
FDU1 4850
FDU1 4860
FDU1 4870
FDU1 4880

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```

TO=KL*K*VTSQ/Y(10)
TO=TO+LSC*KF*KT*Y(10)
TO=T10*VTSQ*TO
ALPA=A*KL/TO
ALPE=Y(1)*DSQ*KT/TO
T1=ALPE-ALPA
T2=T2*KL
IF (IKL*EC*12) GO TO 31
ALPQ1=T1*(V2*DY(9)-V3*DY(8))+ALPB*(V2*G2-V3*G2)
ALPQ2=T1*(V3*DY(7)-V1*DY(9))+ALPB*(V3*G1-V1*G3)
ALPQ3=T1*(V1*DY(8)-V2*DY(7))+ALPB*(V1*G2-V2*G1)
GO TO 32
31 ALPQ1=V2*V1/VTSQ
ALPQ2=-1.+V2*2/VTSQ
ALPQ3=V2*V3/VTSQ
32 ALPE=ALPQ1*2+ALPQ2*2+ALPQ3*2
DKCB=DKCB*ALPE*CSQ
T1=T2*SL*VTSQ
T2=T10*KF*Y(10)*Q
TALPH=ALPE
ALPE1=ALPQ2*V3-ALPQ3*V2
ALPE2=ALPQ3*V1-ALPQ1*V3
ALPE3=ALPQ1*V2-ALPQ2*V1
RMASS=1./Y(1)
DY(7)=(11*ALPQ1+T2*ALPE1)*RMASS
DY(8)=(11*ALPQ2+T2*ALPE2)*RMASS
DY(9)=(11*ALPQ3+T2*ALPE3)*RMASS
CALL PNEST(17,MACH,IALPH,KA)
DY(10)=-T10*D*K*V*Y(10)/A
GO TO 25
33 IE PD=5
IF (IFIRST.EQ.1) CALL SPRINT (Y,DY,1)
34 RETURN
35 TO=SQR(1+REARTH-TO)
EC=Y(5)*(26.42)*J2
GO TO (26,42),Y(4)/TO)
36 T1=Y(8)*(Y(7)*Y(4)/TO)
T2=REARTH*EC/T2
GPH=REARTH*EC/T2
IF (EC*GT.90000.) GO TO 41
IF (GPH*LE.FA(1)) GC TC 42
37 IF (GPH*LE.FA(IMZ*2)) GO TO 38
IMZ=IMZ+1
GO TO 39
38 IF (GPH*GE.FA(IMZ+1)) GO TO 39
IMZ=IMZ+1
GO TO 38
39 TEMF=TEMP(IMZ+1)+ALM(IMZ+1)*(GPH-HA(IMZ+1))

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HDL14890
HDL14900
HDL14910
HDL14920
HDL14930
HDL14940
HDL14950
HDL14960
HDL14970
HDL14980
HDL14990
HDL15000
HDL15010
HDL15020
HDL15030
HDL15040
HDL15050
HDL15060
HDL15070
HDL15080
HDL15090
HDL15100
HDL15110
HDL15120
HDL15130
HDL15140
HDL15150
HDL15160
HDL15170
HDL15180
HDL15190
HDL15200
HDL15210
HDL15220
HDL15230
HDL15240
HDL15250
HDL15260
HDL15270
HDL15280
HDL15290
HDL15300
HDL15310
HDL15320
HDL15330
HDL15340
HDL15350
HDL15360

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```

CY(3)=(-.03416315474*Y(3)*RSQ*TI)/(TEMP*TI2**2)
PA=Y(3)*22.48085431*PRESF
TO=EC
DENS=(Y(3)/TEMP)*.7680191702*DENSF
TEMP=TEMP*TEMPF
VAS=20.04680276*SQRT(TEMP)
4C GO TO (4,13,14),I4
41 GPF=EC
42 GO TO 37
43 IMZ=0
44 GO TO 35
45 TO=EC*AMIOF
46 IF (TO.LE.0.) GO TC 46
47 IF (TO.LE.ATM(IMZ1+8)) GO TO 45
48 IMZ1=IMZ1+7
49 IF (IMZ1.LT.NATM) GC TO 44
50 WRITE (6,52)
51 GO TO IER,(56)
52 IF (TO.GE.ATM(IMZ1+1)) GO TO 47
53 IMZ1=IMZ1-7
54 GO TO 45
55 IMZ1=0
56 TI=(TO-ATM(IMZ1+1))/(ATM(IMZ1+8)-ATM(IMZ1+1))
57 WBX=ATM(IMZ1+2)+TI*(ATM(IMZ1+9)-ATM(IMZ1+2))
58 WSX(1)=WBX
59 WSZ=ATM(IMZ1+3)+TI*(ATM(IMZ1+10)-ATM(IMZ1+3))
60 WBZ=WSZ
61 IF (TO.LE.0.) GO TO 50
62 IF (TO.LE.ATM(IMZ2+11)) GO TO 45
63 IMZ2=IMZ2+7
64 IF (IMZ2.LT.NATM) GO TO 48
65 WRITE (6,53)
66 GO TO IER,(56)
67 IF (TO.GE.ATM(IMZ2+4)) GO TO 51
68 IMZ2=IMZ2-7
69 GO TO 45
70 IMZ2=0
71 TI=(TO-ATM(IMZ2+4))/(ATM(IMZ2+11)-ATM(IMZ2+4))
72 TEMP=ATM(IMZ2+7)+TI*(ATM(IMZ2+14)-ATM(IMZ2+7))
73 TEMPF=TEMPF+273.15
74 DENS=(ATM(IMZ2+5)+TI*(ATM(IMZ2+12)-ATM(IMZ2+5)))*.002204622622
75 PA=(ATM(IMZ2+6)+TI*(ATM(IMZ2+13)-ATM(IMZ2+6)))*22.48085431
76 GO TO 4C
77 FORMAT (24H EXCEEDS METRO FOR WINDS)
78 FORMAT (42H ERROR METRO EXCEEDED FOR DENSITY AND TEMP)
79 FORMAT (15H ROUNC TUMELD ,2F10.3,A5,I5)
80 FORMAT (127H ALPHA VDX GREATER THAN V1 ,2F10.3,A5,I5)
81 FORMAT (21H GONE TC PNEST FM DER)

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FCU15370
FCU15380
FCU15390
FCU15400
FCU15410
FCU15420
FCU15430
FCU15440
FCU15450
FCU15460
FCU15470
FCU15480
FCU15490
FCU15500
FCU15510
FCU15520
FCU15530
FCU15540
FCU15550
FCU15560
FCU15570
FCU15580
FCU15590
FCU15600
FCU15610
FCU15620
FCU15630
FCU15640
FCU15650
FCU15660
FCU15670
FCU15680
FCU15690
FCU15700
FCU15710
FCU15720
FCU15730
FCU15740
FCU15750
FCU15760
FCU15770
FCU15780
FCU15790
FCU15800
FCU15810
FCU15820
FCU15830
FCU15840

```

```

56 RETURN
ENC
SUBROUTINE SPRI (Y,CY,INEST)
DIMENSION Y(16), D(16), LE(1), C, E, LL, GO, TBMST, IBST, IST, PE,
COMMON LE, RN, RK, R2TBM, RNE, XICEL, XIMAX, IH2B, IH3B, QEF, IFUB,
AE, MTBST, MDI, EPB, EUB, EX1, IX1, IX2, MTBM, ATB, ATC, DENSEF, PRESF,
CX1, LZ1, ETB, SL, C, UO, SPN, PTF, A2D, BTBM, LAT, AZ, MCB, UMCB,
IH3, TF, IB, E6, TSCF, CGIB, TI, XI, YI, ZI, WXS, WZ, WEX, WBS,
TSRB, TSCF, THMCB, SL6D
PHMCE, THMCB, TI, XI, YI, ZI, WXS, WZ, WEX, WBS,
TEMPF, ATM(700), IMZ, IMZ1, IMZ2, NATM, J2, IDGREE(1), IRO,
COMMON AT(700), IMZ, IMZ1, IMZ2, NATM, J2, IDGREE(1), IRO,
IREDUC, ITWT, IUPLEG, IUNIT, ISPRI, IRSET, ICURE, ISTIM, ISCOU,
I3DBUR, I3DP, ISAVEG, ITONQE, IXIAYI, I5DIG, IX2N, IUN, LAM(3),
B, AIL, SINCE, COSCE, CSQ, IKL, GORSQ, XOUT(1), YOU, ZCUT, TUF,
AA, AIL, VAS, EC, I2, I3, I4, I5, I6, I7, I8, I9, NEX, ILCA, IRCONS,
CENS, GCRS, I1, I2, I3, I4, I5, I6, I7, I8, I9, NEX, ILCA, IRCONS,
D44, CSQ, RITB, R2TBSQ, RETB, RK12, RK2, RNE, RITE, IRCONS,
IEPD, CSQ, RITB, R2TBSQ, RETB, RK12, RK2, RNE, RITE, IRCONS,
ICNP, I5, I1, I2, I3, I4, I5, I6, I7, I8, I9, NEX, ILCA, IRCONS,
T4, TST, ALP, ITH, THETA, ALPE, ALPQ1, ALPQ2, ALPQ3, CODE, D22, T3,
IFIRST, J1, J7, PDT, PMTOF, UN, YP, V1, V2, V3, TSTAR, KDB,
ICOT2, J1, J7, PDT, PMTOF, UN, YP, V1, V2, V3, TSTAR, KDB,
KM, KL, KT, XDX, XKH, DKDB, DKDBA, MACH, ISUN, SINLAT, COSLAT,
SINAZ, IERR, IERR, IERR, IERR, IERR, IERR, IERR, IERR, IERR,
COMMON /ERR/ IERR, IERR, IERR, IERR, IERR, IERR, IERR, IERR, IERR,
COMMON /ERR/ IERR, IERR, IERR, IERR, IERR, IERR, IERR, IERR, IERR,
1 DTOM, TWCPHI, AMTCIN, AMTOKN, AMTCMH, FTOM2, CVDTOR, CVMTOR, RSQ,
2 HA(23), TM(23), ALM(22), HEAD(169)
REAL IF2B, IH3B, IF2, IH3, IU, IUL, IUN, IST, ISP, IX1, IX2, IX2N,
1 KDB, LAN, LAT, LE, LL, LZ1, LZ2, MFI, MF, MTB, MTBM, MBSI, MACH,
2 KM, KL, KT, KH
DATA PI, P12, P13, 141592654, 1.570796327/
GO TO (1,51), INEST
1 GO TO (49,52,51,292,2), IEPD
2 IFIRST=C
UN=SQRT(Y(7)**2+Y(8)**2+Y(9)**2)
ARSIN WAS ARCSIN
PHI=PDTCN*RTOD*ARSIN(Y(8)/UN)
THETA=PDTCN*RTOD*ATAN(Y(9)/Y(7))
YP=EC
IF (1 YP.EQ.C) YP=Y(5)
UN=PMTCF*UN
IF (16CLF.EQ.1) GC TC 3
T1=Y(1C)/TWOPHI
T2=RTOD*SCRT(ALPE)
AE1=ALFCL

```

C

```

AE2=ALFC2
AE3=ALPC3
GO TO 4
3 IF (A.G1.0.) T1=HD X/(TWCPHI*A)
T2=RTCC*ALPHA
AE1=Y(14)
AE2=Y(15)
AE3=Y(16)
4 IF (T2.G1.0.) GO TO 5
PS I=0.
GO TO 6
5 T3=(V1*AE3-V3*AE1)*VT
T4=Y1*(V1*AE2-V2*AE1)-V3*(V2*AE3-V3*AE2)
IF (T3.NE.0..OR.T4.NE.0.) GO TC 500
PS I=0.
GO TO 6
50C PSI=ATAN2(T3,T4)
IF (PSI.GE.0.) GO TO 6
PSI=TWCCFI+PSI
PSI=RTCC*PSI
6 IF (T6.CF.EG.1) GO TO 7
T3=KDB+LKCB
GO TO 8
7 T3=KDB+LKCB
8 IF (T1.G1.2C.) GO TC 9
TJ (IT+11)=0.0
TJ (IT+12)=0.0
GO TO 15
9 T6=DENS*LC33/Y(1)
T4=T6*(Y(1)*C22/A))
T5=T6*(KL-KT*(Y(1)*C22/B))
T6=KM*LCNS*LC22*D33/B
T7=TWOPHI*T1*D*A/(B*VT)
SDY=2.*T4/T5
SGY=T7*2/(4.*T6)
IDY=0
IGY=0
IF (1./SGY.LT.1.) GC TC 10
IDY=1
IGY=1
IDY=1
GO TO 11
1C IF (1./SGY.LE.SDY*(2.-SDY)) GO TO 11
11 IDY=1
IF (IGY.EQ.1) GO TC 12
SGY=TJ(IT+11)
ENCDCDE (10,58,TJ(IT+11))SGY
GO TO 15
C

```

```

HDL16330
FDU16340
HDL16350
FDU16360
HDL16370
FDU16380
HDL16390
FDU16400
HDL16410
FDU16420
HDL16430
HDL16440
FDU16450
HDL16460
FDU16470
HDL16480
HDL16490
FDU16500
HDL16510
FDU16520
HDL16530
HDL16540
FDU16550
HDL16560
FDU16570
HDL16580
FDU16590
HDL16600
FDU16610
HDL16620
FDU16630
HDL16640
HDL16650
FDU16660
FDU16670
HDL16680
FDU16690
HDL16700
HDL16710
FDU16720
HDL16730
FDU16740
HDL16750
HDL16760
FDU16770
HDL16780
FDU16790
HDL16800

```

```

C      12 SGY=TJ(IT+11)
12 ENCODE (10,59,TJ(IT+11))SGY
13 IF (IDY.EQ.1) GC TC 14
C      14 SDY=TJ(IT+12)
14 ENCODE (10,58,TJ(IT+12))SDY
15 GO TO 15
C      14 SDY=TJ(IT+12)
14 ENCODE (10,59,TJ(IT+12))SDY
15 TJ(IT+1)=Y(2)
TJ(IT+2)=PMTOF*Y(4)
TJ(IT+3)=PMTOF*YP
JAH=0
TJ(IT+4)=PMTOF*Y(6)
TJ(IT+5)=LN
TJ(IT+6)=PHI
TJ(IT+7)=TETA
TJ(IT+8)=T1
TJ(IT+9)=T2
TJ(IT+14)=ICOT 1
TJ(IT+10)=PSI
TJ(IT+13)=CODE
IT=IT+14
IF (I6CP.EQ.0) GO TO 25
TJ(IT+841)=Y(2)
IF (ISLN.EQ.1) GC TC 16
TJ(IT+842)=0.
GO TO 22
16 TLFA=DEL+7.27220521E-5*Y(2)+(Y(4)*SINA2+Y(6)*COSAZ)/((REART*%COSLAT
1
IF (TLFA-PI.GE.0.) GC TC 17
TMERID=TLHA
GO TO 19
17 IF (TLFA-TWCPHI.GE.0.) GO TO 18
TMERID=TWOPHI-TLHA
GO TO 19
18 TMERID=TLHA-TWOPHI
19 SINH=SINLAT*SIND+COSLAT*COSD*COS(TMERID)
H=ASIN(SINH)
Z=ARCCOS((SIND-SINLAT*SINH)/(COSLAT*COS(H)))
IF (TLFA-PI.LT.0.) GO TO 20
IF (TLFA-TWCPHI.GE.0.) GO TO 20
THE=PI2-Z
GO TO 21
20 THE=Z-PI-PI2
21 THE=PI2-F
C      21 CALL SINCCS (PH,SINPH,CCSPH)
SINPH=SIN(PH)
COSPH=CCS(PH)

```

```

FDU16810
FDU16820
FDU16830
FDU16840
FDU16850
FDU16860
FDU16870
FDU16880
FDU16890
FDU16900
FDU16910
FDU16920
FDU16930
FDU16940
FDU16950
FDU16960
FDU16970
FDU16980
FDU16990
FDU17000
FDU17010
FDU17020
FDU17030
FDU17040
FDU17050
FDU17060
FDU17070
FDU17080
FDU17090
FDU17100
FDU17110
FDU17120
FDU17130
FDU17140
FDU17150
FDU17160
FDU17170
FDU17180
FDU17190
FDU17200
FDU17210
FDU17220
FDU17230
FDU17240
FDU17250
FDU17260
FDU17270
FDU17280

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```

C      CALL SINCOS (THE,SINTH,COSTH)
      SINTH=SIN(TH)
      COSTH=COS(TH)
      S1=CO$A$Z*SINPH*SINTH+SINAZ*SINPH*CCSTH
      S2=CO$A$Z*SINPH*CCSTH-SINAZ*SINPH*SINTH
      S3=CO$A$Z*RTOD*ASIN(S1*Y(14)+S2*Y(15)+S3*Y(16))
22      T1=Y(14)
      T2=Y(16)
      T3=RTOD*ATAN2(T2,T1)
      T1=SQR(T1**2+T2**2)
      T2=Y(15)
      T3=RTOD*ATAN2(T2,T1)
      IF (PP1.NE.10000.) GO TO 23
      GO TO 24
23      T1=-(I5*PP1-T7*T4+PPP1)/(2.*PP1-T7)*1000.
      T2=-(I5*PP2-T7*T4+PPP2)/(2.*PP2-T7)*1000.
      ENCODE (40,60,TJ(I1T+845),T1,T2,PP1,PP2
      TJ(I1T+845)=T1
      TJ(I1T+846)=T2
      TJ(I1T+847)=PP1
      TJ(I1T+848)=PP2
      TJ(I1T+849)=TSTAR
      TJ(I1T+850)=Y(1)
      TJ(I1T+851)=B/FTOM2
      TJ(I1T+852)=XDX
      TJ(I1T+853)=CODE
      TJ(I1T+854)=ICOT2
      IT=I1T+14
25      IF (ISPR1.EQ.0) GO TO 26
      TJ(I1T+1667)=Y(2)
      TJ(I1T+1668)=PMTQF*Y(7)
      TJ(I1T+1669)=PMTQF*Y(8)
      TJ(I1T+1670)=PMTQF*Y(9)
      TJ(I1T+1671)=PMTQF*CY(7)
      TJ(I1T+1672)=PMTQF*CY(8)
      TJ(I1T+1673)=PMTQF*DY(9)
      TJ(I1T+1674)=2.546475085*T3
      TJ(I1T+1675)=MACH
      TJ(I1T+1676)=Y(1)
      TJ(I1T+1677)=PMTQF*VT
      TJ(I1T+1678)=CODE
      TJ(I1T+1679)=ICCT3
26      IF (I5CIG.EQ.1) GO TO 54
27      IC1=ICCT1
      ICNP=ICNP+1
28      IF (ICNF.GE.56) GO TO 291

```

```

FDU17290
FDU17300
FDU17310
FDU17320
FDU17330
FDU17340
FDU17350
FDU17360
FDU17370
FDU17380
FDU17390
FDU17400
FDU17410
FDU17420
FDU17430
FDU17440
FDU17450
FDU17460
FDU17470
FDU17480
FDU17490
FDU17500
FDU17510
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FDU17560
FDU17570
FDU17580
FDU17590
FDU17600
FDU17610
FDU17620
FDU17630
FDU17640
FDU17650
FDU17660
FDU17670
FDU17680
FDU17690
FDU17700
FDU17710
FDU17720
FDU17730
FDU17740
FDU17750
FDU17760

```

```

GO TO (252,29), J7
25 ICNP=ICNP+1
GO TO (57,57,57,57,46,57), NEX
291 JAF=1
GO TC 3C
292 IF (JAF.EC.1)GO TO 45
3C K=27
IF (PMTCF.EC.1.) K=14
II=0
J=2
KI=K
KI I=KI+12
IF (IYF.EQ.0) GC TC 31
WRITE (6,61) (HEAD(I),I=1,13)
GO TO 32
31 WRITE (6,61) (HEAD(I),I=157,169)
32 WRITE (6,62) (HEAD(I),I=KI,KII)
33 J=J+1
WRITE (6,63)
34 KI=II+1
KI I=KI+13
WRITE (6,64) (TJ(I),I=KI,KII)
J=J+1
IF (J.EC.58) GO TO 36
IF (IT.EQ.II+14) GO TO 35
II=II+14
IF (TJ(II).EQ.TJ(II+14)) GC TO 34
GO TO 33
35 WRITE (6,63)
36 GO TO (37,41), J7
37 IF (TJ(53).EQ.0.) GO TO 40
IF (J.NE.58) WRITE (6,63)
II=841
J=2
KI=K+35
KI I=KI+12
WRITE (6,61) (HEAD(I),I=40,52)
WRITE (6,62) (HEAD(I),I=KI,KII)
38 WRITE (6,63)
J=J+1
KI I=II+13
39 WRITE (6,65) (TJ(I),I=II,KII)
J=J+1
IF (J.EC.58) GC TO 40
IF (IT.EQ.II-827) GO TC 40
II=II+14
IF (TJ(II-1).EQ.TJ(II+13)) GO TO 39
GO TO 38

```

```

FDL17770
FDL17780
FDL17790
FDL17800
FDL17810
FDL17820
FDL17830
FDL17840
FDL17850
FDL17860
FDL17870
FDL17880
FDL17890
FDL17900
FDL17910
FDL17920
FDL17930
FDL17940
FDL17950
FDL17960
FDL17970
FDL17980
FDL17990
FDL18000
FDL18010
FDL18020
FDL18030
FDL18040
FDL18050
FDL18060
FDL18070
FDL18080
FDL18090
FDL18100
FDL18110
FDL18120
FDL18130
FDL18140
FDL18150
FDL18160
FDL18170
FDL18180
FDL18190
FDL18200
FDL18210
FDL18220
FDL18230
FDL18240

```

```

40 IT=0
GO TO 42
41 IF (Y(2)).LT.IE6) GC TC 37
IF (I6CF.EQ.1) GO TO 37
42 IF (ISFFT.EC.0) GO TO 45
IF (J.NE.58) WRITE (6,63)
II=1681
J=2
K=105
IF (PMTCF.EC.1.) K=92
KI=K+12
WRITE (6,61) (HEAD(I),I=79,91)
WRITE (6,62) (HEAD(I),I=K,KII)
43 WRITE (6,63)
J=J+1
IF (TJ(1692).EQ.0.) GC TO 45
KI=II+12
WRITE (6,66) (TJ(I),I=II,KII)
J=J+1
IF (J.EC.58) GO TO 45
IF (IT.EC.II-1667) GC TC 45
II=II+14
IF (TJ(II-1).EQ.TJ(II+13)) GO TO 44
GO TO 43
45 IT=0
ICNP=3
J7=2
GO TO (57,57,57,46,57), NEX
46 WRITE (6,63)
II=2700
J=2
KI=144
IF (PMTCF.EQ.1.) KI=131
KI=KI+12
WRITE (6,61) (HEAD(I),I=118,130)
WRITE (6,62) (HEAD(I),I=KI,KII)
47 WRITE (6,63)
J=J+1
IF (TJ(2709).EQ.0.) GC TO 49
KI=II+5
WRITE (6,67) (TJ(I),I=II,KII)
J=J+1
IF (I171.EQ.0) GC TC 49
IF (I171.EC.II-2690) GC TO 49
II=II+10
IF (TJ(II-1).EQ.TJ(II+9)) GO TC 48
GO TO 47
48 IT=0

```

```

FDU18250
FDU18260
FDU18270
FDU18280
FDU18290
FDU18300
FDU18310
FDU18320
FDU18330
FDU18340
FDU18350
FDU18360
FDU18370
FDU18380
FDU18390
FDU18400
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FDU18420
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FDU18480
FDU18490
FDU18500
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FDU18550
FDU18560
FDU18570
FDU18580
FDU18590
FDU18600
FDU18610
FDU18620
FDU18630
FDU18640
FDU18650
FDU18660
FDU18670
FDU18680
FDU18690
FDU18700
FDU18710
FDU18720

```



```

N=I+7
BR=AM
K=E(I+1)+1.+FLOAT(I)
IF (B(I).EQ.2.) GO TO 4
DO 1 J=N,K,6
IF (BR.LE.B(J)) GO TO 3
1 CONTINUE
2 WRITE (6,11) I, BR
J=J-1
IF (B(I+1).EQ.2.) J=J-15
WRITE (6,10) (B(I), I=J, K)
GO TO IER, (167)
3 R=B(J-5)+ER*(B(J-4)+BR*(B(J-3)+BR*(B(J-2)+BR*(B(J-1))))
4 RETURN
A2=ALPHA
N=N+13
K=K-15
DO 5 J=N, K, 19
IF (BR.GE.B(J).AND.BR.LE.B(J+19)) GO TO 6
5 CONTINUE
GO TO 2
6 JS=J-3
DO 7 I=1, 2
K=JS
KK=K-14
DO 7 L=KK, K, 2
IF (A2.GE.B(L).AND.A2.LE.B(L+2)) GO TO 8
7 CONTINUE
WRITE (6,12) A2, I, BR
GO TO 2
8 RA(I)=E(L+1)+(B(L-1)-B(L+1))*(A2-B(L+2))/(B(L)-B(L+2))
9 R=RA(2)+(BR-B(J+19))*(RA(1)-RA(2))/(E(J)-B(J+19))
RETURN
10 FORMAT (6E15.8)
11 AERO EXCEEDED CODE=, I4, 12H BREAK PCINT, E15.8)
12 FORMAT (10H ALPHA2 OF, E15.8, 9H FOR TYPE, I4, 12H BREAK PCINT, E15.8)
167 RETURN
END
SUPEROUTINE COA (PY, DPY)
DIMENSION PY(2), DPY(2)
COMMON /BDH/ REARTH, GC, AMTOMS, PO, AMTOF, FICM, ANIOM, RTOD,
1 CTOM, TWCPHI, AMTOIN, AMTOKN, AMTGMH, FTOM2, CVDTOR, CVMTOR, RSQ
2 , HA(25), TM(25), ALP(25), HEAD(169)
J=2
T2=REARTH+PY(1)
GPH=REARTH*PY(1)/T2
1 IF (GPH.LE.PA(J)) GC TO 2

```

```

FDL2C170
FDL2C180
FDL2C190
FDL2C200
FDL2C210
FDL2C220
FDL2C230
FDL2C240
FDL2C250
FDL2C260
FDL2C270
FDL2C280
FDL2C290
FDL2C300
FDL2C310
FDL2C320
FDL2C330
FDL2C340
FDL2C350
FDL2C360
FDL2C370
FDL2C380
FDL2C390
FDL2C400
FDL2C410
FDL2C420
FDL2C430
FDL2C440
FDL2C450
FDL2C460
FDL2C470
FDL2C480
FDL2C490
FDL2C500
FDL2C510
FDL2C520
FDL2C530
FDL2C540
FDL2C550
FDL2C560
FDL2C570
FDL2C580
FDL2C590
FDL2C600
FDL2C610
FDL2C620
FDL2C630
FDL2C640

```


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13537 5

210764

Thesis

P73902 Poole

c.1

Dispersion sensitivity of the eight inch advanced ramjet munitions technology projectile due to wind and minor thrust errors.

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c.1

Dispersion sensitivity of the eight inch advanced ramjet munitions technology projectile due to wind and minor thrust errors.

Dispersion sensitivity of the eight inch



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